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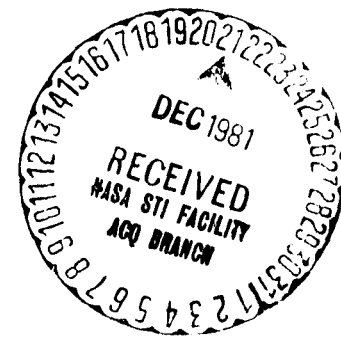
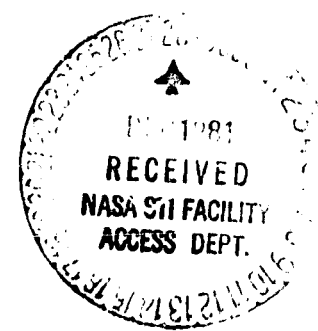
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**Real Time Simulation of Computer-Assisted  
Sequencing and Scheduling of Terminal Area Operations  
Final Report**



by

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## I. INTRODUCTION

Descent guidance of aircraft into high density terminal areas presents the Air Traffic Control (ATC) system with two major concerns - safety and efficiency. Safety is quite naturally the first and foremost concern, while overall system efficiency becomes more and more important as fuel costs and demand for services increase. Moreover, efficiency and safety are interrelated, especially during peak periods. Poor system performance will likely result in additional congestion which will, in turn, produce additional safety-related problems. Recent advancements in navigation and guidance indicate that an aircraft, if properly equipped, can reduce its terminal area fuel consumption and improve its delivery accuracy to the runway. All aircraft, however, are users of the ATC system and must receive ATC clearances in order to execute advanced approaches. The accommodation of these approaches by the ATC system requires a high degree of coordination between final, approach and en route controllers. The controllers may be aided in this task by digital computers. Of particular interest are the potential improvements in system efficiency that may be derived from assisting the controllers with their minute-to-minute decision-making task of sequencing and scheduling arrivals at the runway. The sequencing and scheduling task is of interest because runway utilization is affected by the specific order in which arrivals are served. This is a consequence of the FAA's weight dependent safety separations and also from the differences in aircraft approach and landing velocities.

One decision methodology, termed Constrained Position Shifting

(CPS) has been proposed [1] to sequence and schedule arrivals in a more efficient manner than first-come, first-serve. The CPS methodology essentially determines local derandomizations of the arrival stream whereby all aircraft are subject to a fundamental service constraint. This constraint requires that every aircraft be assigned to land within a pre-specified number of positions from its first-come, first-serve position with respect to arrival at the runway (FCFS-RW). As a consequence, this maximum position shift (MPS) constraint allows the controllers (computers) to resequence the aircraft in a manner that improves overall efficiency while ensuring that no aircraft is inordinately displaced.

In the joint research Interchange Number NCA-OR253-7, the CPS algorithm was adapted so as to be compatible with the real-time simulation facility of the NASA-Ames Research Center's Aircraft Navigation and Guidance Branch. One major accomplishment of this Interchange Number NCA2-OR253-801 was the development of an event-to-event simulation which graphically displays the CPS methodology. The scenario adopted by this demonstration simulation was that of the Denver terminal area (actually a region within a radius of approximately 125 n.m. from Denver's Stapleton Airport). This region and route structure is identical to that selected in the joint NASA/Ames-FAA Technical Center real-time simulation study of profile descents undertaken in July and August, 1977 [2].

A detailed description of the CPS demonstration program plus sample output will be presented. Following the description of the simulation this report will present a discussion on insights gained in

regard to the implementation of the CPS methodology into the updated ATC system. Finally, thoughts on the incorporation of the CPS methodology into the next phase of real-time simulation will be offered.

## II. GRAPHICAL DISPLAY OF CONSTRAINED POSITION SHIFTING

### 1. INTRODUCTION

This section describes the event-to-event simulation developed to demonstrate the CPS methodology on a graphical display. The CPS methodology will generally improve system efficiency whenever runway utilization is dependent upon the specific sequence of arrivals at the runway. This sequence dependence is the rule rather than the exception. A minimum interarrival time separation may be determined for any two successively arriving aircraft. This time separation is a function of the type, weight, capability, and route of both the lead and following aircraft. The CPS methodology will offer improvement over simpler strategies such as first-come, first-serve at the runway (FCFS-RW) unless this minimum time separation is identical for each possible pair of arrivals. Previous fast-time simulations have demonstrated the potential gains of the CPS methodology [1]. Considerable delay reduction is indicated, especially during peak periods. The aircraft in these prior simulations were differentiated by their landing velocities and weight category (light, conventional and heavy). The demonstration simulation described here expands the

CPS methodology to include a three dimensional route structure. As previously mentioned, the terminal area waypoint and route structure is identical to that adopted in the joint NASA-FAA real-time simulation of profile descents into Denver's Stapleton Airport. Flight tracks from the real-time simulation are employed as "nominal" flight paths for the CPS demonstration.

The simulation program described here is written in FORTRAN on a PDP 11/40 computer which drives an Evans and Sutherland "Picture System". The graphics system is connected to three CRTs. The next section offers an overview of the simulation program. Then, instructions for running a CPS demonstration are presented, followed by output and observations from sample runs comparing system performance of the FCFS-RW service discipline to the CPS strategy with a maximum position shift of 4. Limitations and possible extensions to the simulation are then discussed. Finally, a description and listing of the program is provided.

## 2. PROGRAM OVERVIEW

The CPS demonstration simulation may be summarized as follows:

Thirty aircraft arrive in a random fashion (to be described later) into the Denver control area en route to Stapleton Airport. The aircraft flight paths are reproduced from one run of the NASA-FAA profile descent real-time simulation of July 1977. The aircraft identification, position, altitude, and velocity are indicated on the graphical display. The data are updated every four seconds (or any

multiple of four seconds if so selected at run time). Table #1 presents data on the aircraft in the simulation (type, weight, theoretical mix percentage, route number, entrance direction, entrance altitude and velocity, landing velocity, nominal flight time, and whether the aircraft flies a profile descent).

Table #1 - Aircraft Data

A/C TYPE	A/C WEIGHT	APPROX MIX	ROUTE NO.	ENTER FROM	ENT ALT (FT)	ENT VEL (KTS)	LAND VEL (KTS)	NOMINAL FLIGHT TIME	PROF DESC?
DC10	HEAVY	25%	2	SW	37,000	490	152	27m 0s	YES
B737	CONV	20%	4	SE	29,000	460	146	27m 12s	YES
B727	CONV	20%	7	NE	35,000	475	146	23m 44s	YES
DC9	CONV	15%	10	NW	31,000	470	146	24m 56s	YES
CV58	CONV	10%	12	W	21,000	295	141	34m 56s	NO
DHC6	LIGHT	10%	14	N	9,000	155	100	40m 52s	NO

Note that there are six types of aircraft, with each type entering the region from a different direction. The selection of only one type of aircraft for each route was made partly for simplicity, partly due to computer memory limitations, and partly due to the fact that many of the aircraft on the computer tape were instructed to break their profile descents and follow vectoring commands instead. The computations required to schedule different aircraft on the same route are nearly identical to those required for aircraft on different routes. For an explanation, see Section II.E, describing the



scheduling subroutine.

The simulation contains an automated scheduler which determines the tentative runway assignment times by employing the CPS algorithm with a MPS value that is input at run time. The scheduler takes into account the aircraft routes, nominal arrival times at the runway, and weight. Assignment times are calculated such that the FAA minimum horizontal separation standards for co-altitudinal aircraft is never violated. Table #2 presents the minimum separation standards employed in the simulation.

Table #2 - Minimum Separation Standards (n.m.)

		FOLLOWING AIRCRAFT		
		LIGHT	CONV	HEAVY
LEAD AIRCRAFT	LIGHT	3	3	3
	CONV	3	3	3
	HEAVY	6	5	4

Whenever a new arrival enters the Denver control area the automated scheduler must revise its tentative assignment times. At some point in time as an aircraft travels towards the runway the scheduler will change its tentative runway assignment time to a final (fixed) assignment time. The finalization of an aircraft's runway assignment time takes place when one of the following two events occur:

- a) The entrance of any new arrival will not change the aircraft's current assignment; or b) The aircraft is within a pre-specified lead

time from the runway. (A fifteen minute lead time is selected here as a reasonable value, although a simple software revision will change this lead time to whatever value desired.)

Delay is unavoidable whenever the aircraft compete for runway assignments. Holding stacks, path stretching and speed reduction are typical procedures for delay absorption. The simulation identifies delay absorption by holding the delayed aircraft in place and blinking its symbol on the display. This simplification is necessary because all aircraft must follow their predetermined data tracks. All delay, however, will be absorbed prior to the final fifteen minutes of flight. Consequently, the aircraft are under strategic control in the region nearest the airport. This illustrates one advantage of the CPS methodology, namely that the delay will be absorbed in the outer regions of the control area where there is less traffic and the aircraft are relatively fuel efficient.

Finally, when all aircraft have arrived at the runway, the simulation will output relevant statistics for the run. The next section presents instructions for running the CPS demonstration.

### 3. Instructions For Running a CPS Demonstration

This section presents instructions and information necessary to run a demonstration of the CPS methodology. The following section will present results from one such demonstration.

#### A. - Program Preparation

1. Insert disk titled "ROGER DEAR - CPS DEMO" into the PDP-11/40
2. Boot the system
3. Type .R CPSDMO and then RETURN
4. To re-run it is usually necessary to re-boot the system. If a system error occurs, try again. It should run the second time.

#### B. - Simulation Input Parameters

Six input parameters are requested at run-time. They are:

1. SEED - This is any positive integer. The seed number sets the random number generator. Runs may be reproduced with minor variations. (see NOTE at the end of this section)
2. AIRCRAFT POSITION UPDATE - This must be a multiple of 4. The six aircraft data tracks have positional information every 4 seconds. A larger update value will speed up the run. A typical update value might be 28 seconds.
3. FINAL STATISTICS - If a '1' is typed here, only final statistics will be output. If any other number is typed, then arrival information, tentative scheduling assignments and final assignments will also be output. A '1' is recommended.
4. INITIAL DELAY - This must be non-negative. The first aircraft to reach the runway (not necessarily the first aircraft entering the terminal area) will be delayed by the amount input (in seconds). In this manner, an initial busy period may be established.

5. ARRIVAL RATE - This must be non-negative. Arrivals on the same route are separated by a minimum of 92 seconds and the greatest interarrival time (into the terminal area) equals three minutes. Thus this input parameter does not correspond to an exact terminal area arrival rate, but to an approximate value. A large aircraft position update value will also reduce the effective arrival rate. A value between 35 and 45 is appropriate.

6. MPS VALUE - This parameter determines the maximum allowable number of positions that any aircraft may be shifted from its FCFS-RW position. If MPS = 0, then the arrivals are FCFS-RW. A value of MPS = 4 is appropriate for the CPS run. (An MPS value greater than 4 will increase the computational load considerably.)

NOTE - if the input values for the SEED, UPDATE, INITIAL DELAY and ARRIVAL RATE are the same, then an identical stream of aircraft will be generated. For a typical demonstration, it is suggested that the same parameters are input, first with MPS = 0 and then with MPS = 4.

### C. - Scope Information

Three scopes are used for this simulation. They are:

1. The Approach Scene - The approach scene for the Denver terminal area is on the right hand scope in the controller room.
2. The Final Scene - The final controller's scene is located on the left hand scope in the controller's room.

3. Backup Scope - The black and white scope by the terminal may be used to display either the approach or final scene. If the function Switch 1 is set, then the backup scope will show the approach scene. If Switch 1 is not set, then the final scene will be displayed.

#### Other Switches

Two other switches may be used for the demonstration.

SWITCH 3 - If Switch 3 is set, then a region indicating an extension of the runway is displayed on both approach and final scenes.

SWITCH 6 - If Switch 6 is set, then the run will be frozen after the next update. To continue the run, merely turn Switch 6 off and hit RETURN. If desired, the simulation can step through the run by leaving Switch 6 set and hitting the RETURN for each update.

#### D. - Output Information

At the conclusion of the run, output information is sent to the line printer. An explanation of the output is as follows:

1. LAND# - The order of the arrivals at the runway is listed.
2. ENT# - This number identifies the order in which the aircraft enter the terminal area.
3. FCFS# - This number identifies the First-Come, First-Serve number of the aircraft with respect to arrival at the runway. If MPS equals 0, then LAND# and FCFS# are identical.

4. ID - The airline tag is randomly selected. The number following the tag is the same as the aircraft's ENT#. The aircraft is of standard size unless the ID is followed by an "L" (signifying a light aircraft) or an "H" (signifying a heavy jet).

5. ROUTE - Six aircraft types and routes are represented here. The routes, aircraft types and the theoretical percentages for each type are as follows:

ROUTE 2 - DC10 (Heavy) - From the southeast - 25%

ROUTE 4 - B737 - From the northwest - 20%

ROUTE 7 - B727 - From the northeast - 20%

ROUTE 10 - DC9 - From the southeast - 15%

ROUTE 12 - CV58 - From the west - 10%

ROUTE 14 - DHC6 (Light) - From the north - 10%

6. ENTER - This number is the aircraft's terminal area entrance time (in seconds).

7. NOMARR - This is the aircraft's nominal arrival time at the runway (in seconds).

8. SCHED - This is the aircraft's scheduled arrival time at the runway (in seconds).

9. DELAY - This is the aircraft's delay (which equals the difference between the aircraft's scheduled runway assignment time and the aircraft's nominal runway arrival time).

10. TYTOGO - This is the flight time remaining for an aircraft that has received its final assignment at the runway.

11. DELABS - This is the amount of delay that the aircraft has absorbed prior to receiving its final assignment.

12. DEL200 This is the amount of delay that the aircraft must still absorb after receiving its final assignment and prior to arriving at the runway.

NOTE - All aircraft will receive final assignments at least 15 minutes prior to touchdown at the runway. This lead time parameter is fixed, but may be altered by a software change.

#### Other Output

The output also includes the total delay for all 30 aircraft, the average delay for each aircraft, and the effective terminal area arrival rate, which signifies how many aircraft enter the system per hour.

If the response to the question regarding the output of final statistics only is anything other than a "1", then the simulation will output information on each aircraft as it enters the terminal region (identification, route, first-come, first-serve number at the time, and the nominal arrival time at the runway). In addition, the revised tentative assignments are listed. Information is also output whenever a tentative assignment is finalized. This information includes the aircraft identification, route, FCFS-RW number, time when final assignment was delivered, runway sequence position, scheduled arrival time, total delay, delay already absorbed, and delay to be absorbed. Appendix #1 includes a complete output for the demonstration described in the next section.

#### 4. CPS - SAMPLE DEMONSTRATION

This section presents a sample demonstration of the CPS methodology as adapted to the Evans and Sutherland graphics system. The demonstration consists of two nearly identical simulation runs which differ only in the value selected for the MPS parameter. In the first run MPS is set equal to 0, which corresponds to sequencing the arrivals in their FCFS-RW order. The second run will select a MPS value of 4. Differences in the two runs will be observed in order to gain insight into the characteristics of the CPS methodology. In addition to the standard output, photographs of the displays at selected times throughout the two runs will be included.

##### A. The Setup

The responses to the input questions are the same for the two runs (with the exception of the MPS value). Consequently, the arrival process (entrance time, aircraft type, route, etc.) will be identical for each run. These input values are as follows:

1. SEED - The seed number for this demonstration is 1777. The resultant traffic mix is:

ROUTE	AIRCRAFT TYPE	SIZE	NUMBER GENERATED	PERCENT
2	DC10	HEAVY	7	23.33
4	B737	CONV	7	23.33
7	B727	CONV	8	26.67
10	DC9	CONV	3	10.00
12	CV58	CONV	2	6.67
14	DHC6	LIGHT	3	10.00



2. UPDATE INTERVAL - The update interval equals 8 seconds.

3. ARRIVAL RATE (approximate) - The input value for the arrival rate is 45 aircraft per hour. The arrival process is not quite Poisson since aircraft that are on the same route must be separated initially by 92 seconds. Also, the maximum interarrival time is set to three minutes. As a consequence, the thirty aircraft in the demonstration all arrive within 35 minutes, which corresponds to an effective arrival rate of 52.84 aircraft per hour. The value selected is on the high side, since heavier arrival rates illustrate the differences between FCFS-RW and the CPS methodology more dramatically.

4. INITIAL DELAY - An initial delay of five minutes is selected. A positive initial delay forces the first aircraft to be delayed which establishes an initial busy period. Since the simulation run is limited to thirty aircraft, the use of an initial delay will more accurately represent peak period conditions.

#### B. The Output

Tables #3 and #4 present the summary output for the FCFS-RW run (MPS = 0) and the MPS = 4 run respectively. (Appendix #1 contains the complete output for each run.)

A number of observations and comments are in order. First, notice that in the MPS = 4 run the average delay for an aircraft was reduced from 237.20 seconds to 194.53 seconds (an approximate savings of 18%). The savings were realized by a more effective utilization of

# Table #3-Summary Output-FCFS-RW

SEED # = 1777 UPDATE INTERVAL = 8 ARRIVAL RATE = 45 MPS = 0

LAND#	ENT#	FCFS#	ID	ROUTE	ENTER	NOMARR	SCHED	DELAY	TYTOGO	DELABS	DEL2GO
1	1	1	UA 1	10	8	1504	1804	300	1468	0	300
2	3	2	TW 3	10	256	1752	1872	120	1480	0	120
3	2	3	TW 2H	2	188	1808	1940	132	1508	0	132
4	6	4	CO 6	7	428	1852	2056	204	1592	0	204
5	4	5	TW 4	10	384	1830	2124	244	1596	60	184
6	7	6	CO 7	7	520	1944	2196	252	1508	168	84
7	10	7	UA10	7	680	2104	2268	164	1508	80	84
8	8	8	CO 8	4	544	2176	2340	164	1532	0	164
9	12	9	CO12	7	800	2224	2412	188	1564	48	140
10	9	10	WA 9	4	636	2268	2484	216	1540	116	100
11	11	11	WA11	4	728	2360	2556	196	1612	96	100
12	14	12	WA14	7	936	2360	2628	268	1564	124	144
13	13	13	WA13	4	852	2484	2700	216	1492	144	72
14	15	14	CO15H	2	1008	2628	2768	140	1552	0	140
15	18	15	FL18	7	1212	2636	2884	248	1580	64	184
16	16	16	CO16H	2	1100	2720	2952	232	1560	140	92
17	17	17	CO17H	2	1192	2812	3044	232	1612	180	52
18	5	18	T' 5L	14	400	2852	3212	360	1700	0	360
19	19	19	UA19H	2	1312	2932	3280	348	1736	204	144
20	22	20	CO22	7	1540	2964	3396	432	1500	0	432
21	27	21	FL27	7	1888	3312	3468	156	1564	0	156
22	24	22	UA24H	2	1704	3324	3536	212	1592	48	164
23	25	23	CO25	4	1732	3364	3652	288	1636	0	288
24	20	24	TW20	12	1336	3432	3720	288	1648	0	288
25	26	25	TW26	4	1856	3488	3792	304	1632	92	212
26	28	26	FL28	4	1948	3580	3864	284	1616	160	124
27	29	27	TW29H	2	2044	3664	3932	268	1596	0	268
28	23	28	UA23	12	1656	3752	4064	312	1672	36	276
29	21	29	WA21L	14	1360	3812	4160	348	1248	0	348
30	30	30	WA30L	14	2052	4504	4504	0	896	0	0
TOTAL DELAY =										7116	

MAXIMUM NUMBER OF POSITION SHIFTS = 0  
EFFECTIVE ARRIVAL RATE INTO THE TERMINAL AREA = 52.84 PER HOUR  
AVERAGE DELAY PER AIRCRAFT = 237.20 SECONDS

# Table #4 - Summary Output - MPS = 4

SEED # = 1777 UPDATE INTERVAL = 8 ARRIVAL RATE = 45 MPS = 4

LAND#	ENT#	FCFS#	ID	ROUTE	ENTER	NOMARR	SCHED	DELAY	TYTOGO	DELABS	DEL2GO
1	1	1	UA 1	10	8	1504	1804	300	1276	0	300
2	3	2	TW 3	10	256	1752	1872	120	1184	0	120
3	4	5	TW 4	10	384	1880	1940	60	1180	12	48
4	6	4	CO 6	7	428	1852	2012	160	1204	0	160
5	7	6	CO 7	7	520	1944	2084	140	1236	20	120
6	10	7	UA10	7	680	2104	2156	52	1212	28	24
7	2	3	TW 2H	2	188	1808	2224	416	1312	0	416
8	8	8	CO 8	4	544	2176	2340	164	1276	0	164
9	12	9	CO12	7	800	2224	2412	188	1204	4	184
10	9	10	WA 9	4	636	2268	2484	216	1268	132	84
11	11	11	WA11	4	728	2360	2556	196	1252	196	0
12	14	12	WA14	7	936	2360	2628	268	1236	124	144
13	13	13	WA13	4	852	2484	2700	216	1268	144	72
14	18	15	FL18	7	1212	2636	2772	136	1260	40	96
15	5	18	TW 5L	14	400	2852	2868	16	1324	0	16
16	15	14	CO15H	2	1008	2628	2936	308	1208	0	308
17	16	16	CO16H	2	1100	2720	3028	308	1124	176	132
18	17	17	CO17H	2	1192	2812	3120	308	1176	216	92
19	19	19	UA19H	2	1312	2932	3212	280	1196	260	20
20	22	20	CO22	7	1540	2964	3328	364	1264	0	364
21	27	21	FL27	7	1888	3312	3400	88	1240	0	88
22	20	24	TW20	12	1336	3432	3468	36	1220	0	36
23	25	23	CO25	4	1732	3364	3540	176	1204	0	176
24	26	25	TW26	4	1856	3488	3612	124	1220	4	120
25	28	26	FL28	4	1948	3580	3684	104	900	104	0
26	24	22	UA24H	2	1704	3324	3752	428	1328	0	428
27	29	27	TW29H	2	2044	3664	3844	180	900	180	0
28	23	28	UA23	12	1656	3752	3976	224	1120	0	224
29	21	29	WA21L	14	1360	3812	4072	260	1160	0	260
30	30	30	WA30L	14	2052	4504	4504	0	896	0	0
TOTAL DELAY = 5836											

MAXIMUM NUMBER OF POSITION SHIFTS = 4  
EFFECTIVE ARRIVAL RATE INTO THE TERMINAL AREA = 52.84 PER HOUR  
AVERAGE DELAY PER AIRCRAFT = 194.53 SECONDS

the runway. Note, for instance, that WA21L is the 29th and last aircraft in the busy period for both runs. In the FCFS-RW run, WA21L is scheduled to land at 4160 seconds, as compared to 4072 seconds in the MPS = 4 run. Thus the same 29 aircraft are serviced faster in the MPS = 4 case, which implies an increase in capacity. (If the busy period were to continue, additional arrivals would benefit from this 88 second improvement in runway utilization.) The potential increase in capacity that results from employing the CPS methodology is closely related to the range of minimum interarrival time separations between successively arriving aircraft. For example, if all aircraft interarrival time separations are identical, then there would be no possible improvement over FCFS-RW. In general, the CPS methodology will be more likely to shift an aircraft with a large range of interarrival time separations. For instance, as a consequence of the weight-dependent separation distances established for following heavy jets, the CPS methodology will tend to "bunch" heavy jets together wherever possible. Whether or not a bias exists towards forward or rearward shifts can not be determined until the specific traffic mix is known. The "bunching" together of heavy aircraft is evidenced in the MPS = 4 run. In this particular sample, the "bunching" is accomplished via rearward shifts, although in other circumstances forward shifts would be utilized. Notice that five of the seven heavy jets are shifted rearward and that all other aircraft are either sequenced in their FCFS-RW position (17 aircraft) or are shifted

forward (B aircraft). In peak periods, the improvements in runway utilization will typically offset any delay caused by rearward shifts. For instance, WA29H is sequenced 27th in both runs. The MPS = 4 run, however, schedules WA29H 88 seconds sooner than the FCFS-RW run. Light and slow aircraft will also experience a greater extreme of position shifts, although the limited demonstration presented here has too small a sample to produce any observable trends.

### C. CPS Demonstration - Photographs

In order to illustrate the progress of the aircraft through the terminal area, this section presents photographs taken at four identical time instants selected from each demonstration run. Actually, five photographs are presented from each run. At 28 min 16 sec (1696 sec) snapshots of both approach and final displays were taken. Only the final display is seen in photographs taken at 41 min 36 sec (2496 sec), 54 min 24 sec (3264 sec) and 59 min 4 sec (3544 sec). The approach scene includes a region of approximately 250 square n.m., while the final region contains approximately 90 square n.m. For reference, a 3 n.m. cross is shown in the left center of the displays. Photographs numbered 1 through 5 correspond to the FCFS-RW run, and those numbered 6 through 10 correspond to the MPS = 4 run. The approach display is seen in photographs 1 and 6. Twenty-three aircraft may be identified, although those aircraft in the near vicinity of the runway are better observed in the final scene photographs numbered 2 and 7 respectively. Note that the aircraft

shown in the final scenes are all properly separated by the automated scheduler (recall that the final 15 minutes of flight is essentially strategic). In comparing the two sequences of photographs, one might observe that there is little to distinguish between the two runs. This point is significant in the respect that the CPS methodology need not place an extra burden on the final controllers (as compared to sequencing in a first-come, first-serve manner). In other words, provided that the aircraft absorb their delay fifteen minutes prior to touchdown, the MPS = 4 sequence is no more complicated than FCFS-RW. As a matter of fact, the MPS = 4 sequence might even be easier to implement, since the CPS methodology will tend to group similar aircraft together, whereas the FCFS-RW sequence is subject to all the vagaries of the random arrival process.

#### D. CPS Demonstration - Limitations and Extensions

This section presents a discussion on limitations and possible extensions to the CPS demonstration simulation as currently configured. Section III will also discuss extensions, but in reference to the design of a real-time simulation study. Future extensions to this simulation may nevertheless be useful as a developmental aid for a real-time simulation study. Three major limitations of the current simulation are discussed below. In addition, an attempt is made to estimate the effort required to expand the simulation.

The first major limitation is related to the number and mix of aircraft. The use of six aircraft types arriving from separate

directions has succeeded in providing sufficient diversity to offer a good overview of the CPS methodology. For more realism however, extensions should be performed that will allow more than 30 aircraft in a run and will include a traffic mix more representative of the region to be simulated. The addition of more aircraft will require a simple software change. Adding more aircraft types and/or routes is conceptually easy, but it is doubtful that the PDP-11/40 could handle many more data tracks without exceeding its memory limits. Also, an expansion of the scheduling subroutine is required for each additional aircraft type and/or route.

The second major limitation to the CPS demonstration is related to the fact that the CPS algorithm is totally automated. In order to implement the CPS methodology, it will be necessary to develop an interactive decision-making process with the controller. This includes procedures for the controller to input requests and constraints that the computer will consider when determining its tentative assignments. In addition, a controller-computer interface will be necessary to finalize the runway assignments. The programming effort required for this extension is quite large. The general scheduling problem with controller interaction is non-trivial for all but the simplest types of constraints. Also, it will be necessary to add another display that will present the scheduling information to the controller. Once again, it is doubtful that the PDP-11/40 could handle the added software on a stand-alone basis.

The third major limitation to the current demonstration is related to the actual flight paths placed on the graphic displays. Since the flight paths are pre-determined and fixed, the only way to delay an aircraft has been to literally stop it in its track until its delay period had elapsed. Other aircraft that were following the delayed aircraft would have to be held as well in order to avoid overtaking. The expansion of the simulation to include realistic and variable flight paths would require access to a pseudo-pilot routine such as that employed in the joint NASA-Ames - FAA real-time simulations. Towards this end, the CPS demonstration has been designed to interface directly with the Sigma computer that drives the pseudo-pilots. Only minor modifications will be required to display the pseudo-aircraft, but a considerable effort will be required to adapt the scheduler. Another major task will be the development of ATC procedures for delay absorption.

To summarize, most extensions to the current simulation require either considerable additional programming or access to larger computers or both. One area of interest which could support independent investigation is the development of the controller-computer interface required for interactive sequencing and scheduling.

#### E. CPS Demonstration - Program Description

This section describes the demonstration program. Appendix #2 contains a complete listing of the main program and the subroutines.



In addition to the main program, 17 subroutines are included. These subroutines fall into one of five categories: 1) initialization; 2) display processing; 3) aircraft control; 4) sequencing and scheduling computations; and 5) output control. Table #5 lists and briefly describes the subroutines associated with the first three categories, and Table #6 does the same for the last two categories.

Table #5 - Subroutine Description  
Categories 1), 2), and 3)

1) Initialization Subroutines -

SPINIT - This subroutine sets up the direct access files for the six types of aircraft.

SETUPR - This subroutine requests the input parameters for a demonstration run.

2) Display Processing Subroutines -

BLDESX - This subroutines draws the routes and waypoints on the Evans and Sutherland graphical displays.

ACDRAW - This subroutine draws the proper aircraft symbols and flight data tags on the displays.

FRMSGX - In the profile descent simulation, this subroutine drew the flight data table on the display. In the demonstration program, FRMSGX does not process any data.

3) Aircraft Control Subroutines -

SIGIOX - In the profile descent simulation, this subroutine controlled the PDP link to the Sigma computer (and the pseudopilots). In the demonstration simulation SIGIOX calls subroutine UPDB.

UPDB - This subroutine updates the aircraft positions as referenced by the direct access files. Also, aircraft that have landed are remove by UPDB.

GENERB - This subroutine randomly selects the characteristics of the next arrival.

INITDL - This subroutine determines if a new arrival must incur an initial delay.

Table #6 - Subroutine Descriptions  
Categories 4) and 5)

4) Sequencing and Scheduling Subroutines -

**SORT-** This subroutine sorts the latest arrival into its FCFS-RW position.

**GETSET** - This subroutine determines the set of aircraft that are to be scheduled during an iteration of the CPS algorithm.

**GETPRM** - This subroutine selects the next permutation to be tested from the set of aircraft determined by GETSET.

**FEZTST** - This subroutine tests the latest permutation to determine whether or not it violates any of the sequencing constraints.

**SKEDUL** - This subroutine schedules the runway assignment times for each feasible permutation. The schedule upholds the FAA minimum separation distances for co-altitudinal aircraft.

**COMPAR** - This subroutine tests and saves the best of the feasible permutations.

**MKEFNL** - This subroutine determines when an aircraft is to receive its final assignment.

5) Output Control Subroutine -

**OUTR** - This subroutine controls the data that are output during and after the simulation run.

The program also includes a number of subroutine calls and commands that control the Evans and Sutherland "Picture System". Table #7 lists without explanation those system commands that are utilized in the demonstration program to drive the graphical displays. For additional information, refer to the proper "Picture System" operations manual.

Table #7 - Picture System Commands

PSINIT	CHAR	POP
PUSH	STARTC	READC
NUFRAM	SCOPE	ENCODE
VWPORT	WINDOW	DRAW2D
ISWSET	MOVETO	LINETO
TEXT	BLINK	

The subroutines in category 4) are nearly identical to those written for the CPS algorithm under Interchange No. NCA-OR253-7. There is, however, a significant change in the scheduling subroutine, SKEDUL. Consequently, this subroutine will be described in greater detail. Basically, the scheduling subroutine determines the runway assignment times for a particular feasible permutation of arriving aircraft via an interactive process. To elucidate, the runway assignment time for a following aircraft depends on the type and route of both the lead and following aircraft, and the runway assignment time of the lead aircraft. The routes of the lead and following aircraft are important because the point of closest approach between the aircraft must be determined. In the CPS demonstration simulation, the closest approach between two successively arriving aircraft will occur at one of six merge points (including the runway). If the following aircraft is overtaking the lead aircraft, then the merge point will be at the runway. If the lead aircraft is faster, then an opening situation exists, and the closest approach will occur at the first intersection of the aircraft routes. The closest approaches are defined in the subroutine SKEDUL by the array MERGE.

Once the point of closest approach has been established, the interarrival time separation is determined by calculating the difference between the following aircraft's travel time to the runway and the lead aircraft's travel time to the runway, assuming that the aircraft start at their point of closest approach. (Of course, the following aircraft will be behind the lead aircraft by the appropriate FAA separation minimum.) The remaining travel time for each aircraft type at each merge point is contained in the array TYTOGO. A third dimension is required to differentiate between the various FAA separation minima that might be in effect. A parameter SEP is utilized to distinguish between these minima. When SEP equals 1, the time to travel is calculated from the merge point. A SEP value of 2 corresponds to following a conventional aircraft, while SEP=3 corresponds to following a heavy jet, and finally SEP=4 corresponds to following a light aircraft. In order to add more aircraft types or different types of aircraft on the same route it is necessary to determine the merge points for the added aircraft with every other aircraft in the system. Also, the remaining travel time from any merge point must be calculated for each separation minimum. While these calculations are straightforward, there is a definite increase in the time required to set up the terminal area scenario.

### III. Implementation of Computer-Assisted Sequencing and Scheduling

#### 1. Introduction

The air traffic control system which incorporates computer-assisted sequencing and scheduling will evolve from the current system with one fundamental difference - the control of the aircraft will be in a time-based frame of reference as opposed to the current distance-oriented reference. This section examines the system requirements necessary to support computer-assisted sequencing and scheduling. Also presented is an overview of a time-based system from the perspectives of both pilots and controllers. For simplicity, the overview will initially assume that the aircraft will be sequenced and scheduled in their first-come, first-serve order with respect to arrival at the runway (FCFS-RW). Next, the system characteristics for FCFS-RW will be compared to those resulting from more efficient sequencing strategies. Finally, some implementation-related design considerations will be discussed.

In a time-based control system the aircraft will be instructed to reach a particular point in the airspace at a given point in time. As a consequence, the effectiveness of a time-based control concept will in large measure be dependent upon the aircraft delivery accuracy (in space and time). Technological advances in the fields of communication, data processing and navigation may be utilized to provide the necessary accuracy. For instance, a digital data link between the pilots and controllers may be used to reduce pilot

response time to commands. This data link can also exchange a wealth of other information. As a consequence the system's surveillance and tracking capabilities may be greatly enhanced. Processed data might be uplinked to the aircraft to offer ground-based assistance to aircraft lacking sophisticated navigational instrumentation. A cockpit display of traffic information is another system capability. Such a display might be used to assist in the safe separation of aircraft and in the maintenance of the orderly flow of traffic. Instrumentation such as area navigation (RNAV) will also assist the pilot in delivery accuracy. Those aircraft equipped with four dimensional area navigation (4D-RNAV) will be able to traverse the terminal area with little controller intervention. Aircraft without 4D-RNAV may still be controlled in time, provided that the ATC system's data processing and communication capabilities are employed to supplement the aircraft's own navigational system. The instrumentation required for these applications are either available today or may be available in the near future. The next section explores the general characteristics of a system designed to incorporate these technological advancements.

## 2. Time-Based Control - A System Overview

This section presents an outline of the proposed time-based control system from the perspectives of both the arriving aircraft and the controllers. For this discussion it is assumed that the aircraft are capable of sufficient delivery accuracy to permit time-based

control. In general, aircraft that have greater variability in delivery may be dealt with by increasing the surrounding time buffer that the automated scheduler establishes for safety. An added time buffer, however, might increase delays to such an extent as to make the time-based approach undesirable. (Only a full-blown analysis of a specific system will provide the answer to this question.) This discussion also assumes that the aircraft are to be sequenced in a first-come, first-serve manner (FCFS). To be precise, the FCFS discipline requires the specification of a reference point in the airspace (e.g. the point of system entrance, the runway threshold, the outer marker, etc.). In general, the arrival sequence (and system efficiency) is influenced by the reference point selection. This is a consequence of the variations in aircraft capabilities and approach routes. Since the runway is the system's bottleneck, FCFS-RW will be the FCFS discipline with the greatest runway capacity. The system overview is independent of the FCFS reference point, although the aircraft delay will be sensitive to this selection. The following is a general overview, since any attempt to identify system specifications at this stage of development is premature. To begin, the sequence of events from the perspective of an arriving aircraft is as follows:

1. Approximately 25-40 minutes prior to the arrival at the runway, the ground-based computer requests any updates to the current data on aircraft type, capabilities and approach route.

2. If there is sufficient congestion such that delay is unavoidable, then the aircraft will receive instructions to absorb the delay while at the higher altitudes (where the aircraft is relatively fuel efficient).

3. Following the initial delay absorption (if any), the aircraft receives its descent clearance on a specified route. A tentative arrival time is provided and if so equipped, the aircraft's on-board navigational system will determine the aircraft's most efficient trajectory. A cockpit display of traffic might be employed to help one aircraft follow another.

4. Approximately 15 to 20 minutes prior to touchdown the aircraft receives its final runway assignment time. The assignment will become finalized if either a) no other aircraft can enter the system with a earlier FCFB number, or b) a predetermined lead time has been reached. If the aircraft's final assignment time differs from its current tentative assignment, the aircraft will either utilize its on-board navigational capabilities or controller commands or both to revise its current trajectory.

5. The final 15-20 minutes of flight is essentially automatic. The pilot might employ a cockpit display of traffic to monitor the surrounding aircraft and inform the controller of any difficulties. Otherwise, the aircraft will follow its revised trajectory until touchdown (or until the final controller activates alters the aircraft's final approach).



Now consider an aircraft's progress through the terminal area from the controller's perspective. Once again it is assumed that the aircraft are capable of accurately following the controller's commands. The sequence of events as seen by the controller is as follows:

1. Approximately 25-40 minutes prior to arrival at the runway the ground-based computer requests an update to the aircraft's data file. The file contains information regarding the aircraft's type, capabilities and approach route.
2. The ground computer next calculates the aircraft's nominal arrival time at the runway and determines the amount of unavoidable delay (if any). Unavoidable delay may be defined as that delay which must be incurred under normal circumstances. The controller will supply the pilot with instructions as to how the delay should be absorbed.
3. The arriving aircraft's FCFS sequence is determined and its tentative runway assignment time is calculated by an automated scheduler. The automated scheduler utilizes the aircraft size, type, route, and capability data to compute runway assignment times that uphold the FAA's minimum separation requirements and also provide a sufficient buffer to account for delivery inaccuracies.
4. The tentative assignment times are finalized by the controller approximately 15-20 minutes prior to touchdown. Either the predetermined lead time has been reached or the entrance of additional aircraft will not alter the aircraft's current runway assignment time.

5. After the final assignment has been provided, the final controller might revise the aircraft's trajectory, but in general the final controller will primarily monitor the aircraft with final assignment times to insure that they remain on schedule.

These two perspectives have assumed that the aircraft are sequenced by a FCFS discipline (with respect to a given reference point). For any particular sequence the automated scheduler will determine the aircraft runway assignment times such that safe separation is always maintained. A revision to the current FCFS sequence might be required when a relatively fast aircraft enters the system. (That is unless the FCFS reference point is the system entrance.) When such a situation arises the automated scheduler must also revise its assignment times. Aircraft with FCFS arrival times less than that of the fast new arrival will retain their current assignment, while aircraft with greater FCFS arrival times will be shifted rearward by one position. As a consequence, the airspace may be viewed as consisting of an inner strategic control region and an outer dynamic control region. Aircraft in the inner region will have fixed assignment times while aircraft in the outer region have tentative assignment times. The boundary between the two regions will be determined by the time required for the fastest aircraft to fly the shortest arrival route. If the boundary is too close to the runway, the controllers may wish to define their own boundary by requiring the aircraft to receive their final assignments a given lead time prior to

touchdown. The effect of such a lead time would be to stabilize the inner region at the possible expense of sequencing arrivals in something other than a strict FCFS order. (This situation arises whenever a new arrival has a FCFS number lower than that of an aircraft that has already received its final assignment.) Since the FCFS discipline with a non-zero lead time results in general resequencing and rescheduling, and since the resulting sequence might not be strictly FCFS, the question arises as to whether other sequencing disciplines might be utilized with similar characteristics but greater efficiency. These other strategies might consider the aircraft operating characteristics that the FCFS discipline does not (such as weight class differentiation). The next section explores the system characteristics of more flexible sequencing and scheduling disciplines such as Constrained Position Shifting (CPS). Of particular interest are the differences and similarities between the CPS disciplines and FCFS as perceived by the controllers and pilots.

### 3. Operational Comparison of FCFS and CPS Strategies

The first-come, first-serve strategy is perceived as a 'fair' and efficient service discipline. Such a strategy may be observed in numerous service systems (e.g. banks, post offices, theatre box offices, etc.). In terms of efficiency, when individual service times are independent and stationary, then the total FCFS service time for a given set of customers will be no greater than any other sequencing strategy. In the ATC system, however, service times will be

independent only if all aircraft have the same operating characteristics. Due to the differences in aircraft velocities and the FAA's weight dependent separation minima, the total service time for a particular set of arrivals will generally depend upon the specific runway sequence selected. As a result, sequencing strategies such as Constrained Position Shifting (CPS) will, when compared to FCFS reduce average delay and increase runway capacity. In other words, FCFS may be 'fair', but not necessarily efficient. This section compares the operational characteristics of FCFS-RW to the CPS methodology. Of interest are the adaptations required to implement the CPS methodology as opposed to FCFS-RW (as described in the previous section). Recall that the CPS strategy establishes a maximum position shift (MPS) parameter which limits the number of positions that any aircraft might be shifted (forward or rearward) from its FCFS-RW position. The MPS constraint will cause a local "derandomization" of the arrival stream that will typically reduce total delay and increase aircraft throughput. In actuality, the FCFS discipline is a CPS strategy with  $MPS=0$ . Thus this discussion will focus on the system response as MPS increases from 0. A representative value for the MPS parameter in an actual system might be 4 or 5. MPS values much greater than 5 tend to be inequitable, i.e., the average delay for certain classes of aircraft will increase rather than decrease.

Operationally, when an aircraft enters the system the pilot is

concerned with the aircraft's runway assignment time and how much delay might be incurred. The pilot is not necessarily interested in the aircraft's FCFS-RW number. This is especially true when employing CPS, since it is quite possible for an aircraft to be shifted rearward and yet have an earlier runway assignment time. For the most part, the pilots will not perceive any major differences in operations when MPS increases from 0 to 4 or 5. There will be the potential for some aircraft to have greater delay with a larger MPS value because of the possibility of rearward shifts. The increase in maximum delay can be upper bounded by  $MPS \cdot T$ , where  $T$  represents the maximum interarrival time separation between successively arriving aircraft. For example, if  $T$  equals 3 minutes and  $MPS=4$ , then 12 minutes is a conservative upper bound on the additional delay that any aircraft might receive. During periods of heavy traffic it is quite likely that the increases in aircraft throughput with CPS will more than offset any increases in delay caused by rearward shifts. Another effect of increasing the MPS value will be a change in the boundary between the inner and outer control regions. As MPS increases the potential for resequencing also increases and consequently the runway assignments will be finalized later - thereby moving the inner region boundary closer to the runway. An appropriately selected lead time might minimize this effect. In regard to traffic flow, the CPS methodology might actually make the pilots' merging tasks easier. This is due to the tendency for the CPS methodology to group like aircraft. This clustering effect may aid

traffic flow since it is generally easier to follow an aircraft with a similar velocity profile, especially when assisted by a cockpit display.

The differences in the FCFS-RW and CPS disciplines are more pronounced for the controllers than the pilots. Actually, the differences are significant in the outer control region but not the inner control region. In the inner control region, all aircraft have received their final runway assignment times, and since these aircraft will not be resequenced, the service discipline will no longer be a factor. In the outer control region the aircraft receive tentative assignments. When a new aircraft enters the system the tentative assignments may have to be revised. Utilizing the FCFS-RW strategy the resequencing and rescheduling is straightforward. All aircraft with nominal arrival times greater than that of a new arrival will be shifted rearward one position. The resequencing task becomes more complex when a non-zero MPS is employed. The MPS value places a constraint on the extent of shifting from FCFS-RW, and in general, more than one feasible sequence will exist. As a consequence, the controllers must specify the criteria to be used to determine which of the feasible sequences are most favorable. This specification may be accomplished either implicitly (by supplying objectives and weights to the automated CPS algorithm), or explicitly (by designing an interactive algorithm which solicits added constraints or objectives from the controllers). The controllers will be able to adjust their

tentative assignments for practical reasons when a non-zero MPS value is employed, while using the FCFS-RW strategy the controllers will be a passive element in regard to the sequencing decisions. Of course the algorithms developed to interact with the controllers must be carefully designed and tested to ascertain their potential for both efficiency and successful implementation. The final section will offer insights into the design of this interactive system.

#### 4. Implementation-Related Design Considerations

A successful time-based control system must combine the best elements of both computers and controllers. The data processing capability should be utilized to rapidly determine the best sequence and schedule subject to particular controller-imposed constraints. The controller should be utilized to supply those constraints that, based upon experience, will result in an orderly flow of traffic. In addition to determining effective decision-making objectives, the designer of the time-based ATC system must be concerned with a number of implementation problems. Of course extensive system development and testing is necessary prior to any actual implementation. Some of these issues pertain to the design of a general ATC system, while other questions must be related to the particular terminal area system to be designed. This section concludes by listing some of these implementation concerns.

1. What procedures are the aircraft to follow to absorb delay? How will these procedures depend upon the amount of delay, the aircraft's

capabilities, the aircraft's location, and the surrounding traffic.

2. How accurately are the nominal flight paths followed? What should be done with an aircraft that falls behind schedule? Are there any speed-up procedures? How far behind schedule must an aircraft be before the tentative sequence is revised?

3. How should the system handle missed approaches? What protocol should be adopted to resequence missed approaches? What will happen to the assignments and flight paths of the other aircraft?

4. How does the system respond when an aircraft has an emergency situation? Can priority service be provided when necessary? What will happen to the other aircraft in this situation?

5. What happens in the event of a computer outage or a runway closure? What protocol will be established for the aircraft to follow? How should the system restart itself once the problem has been resolved?

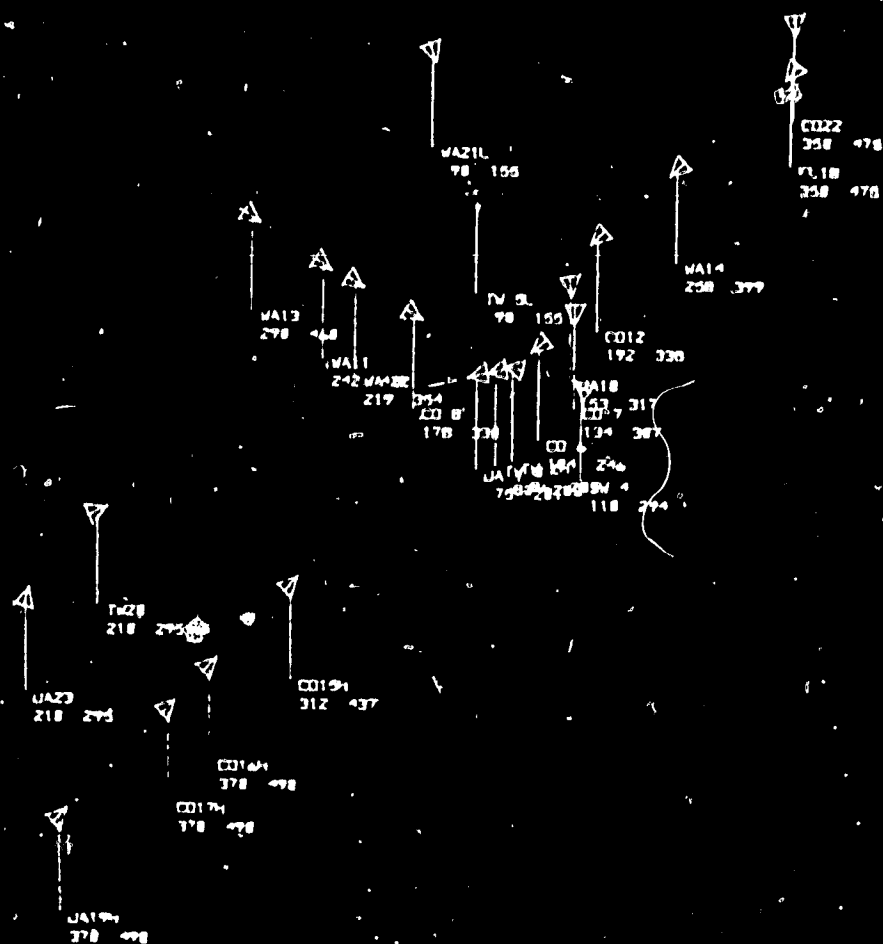
6. What minimum instrumentation should be required before an aircraft is permitted to enter a high density terminal area? How will the system mix the lesser equipped aircraft with those that are more advanced and sophisticated? Are any special procedures required?



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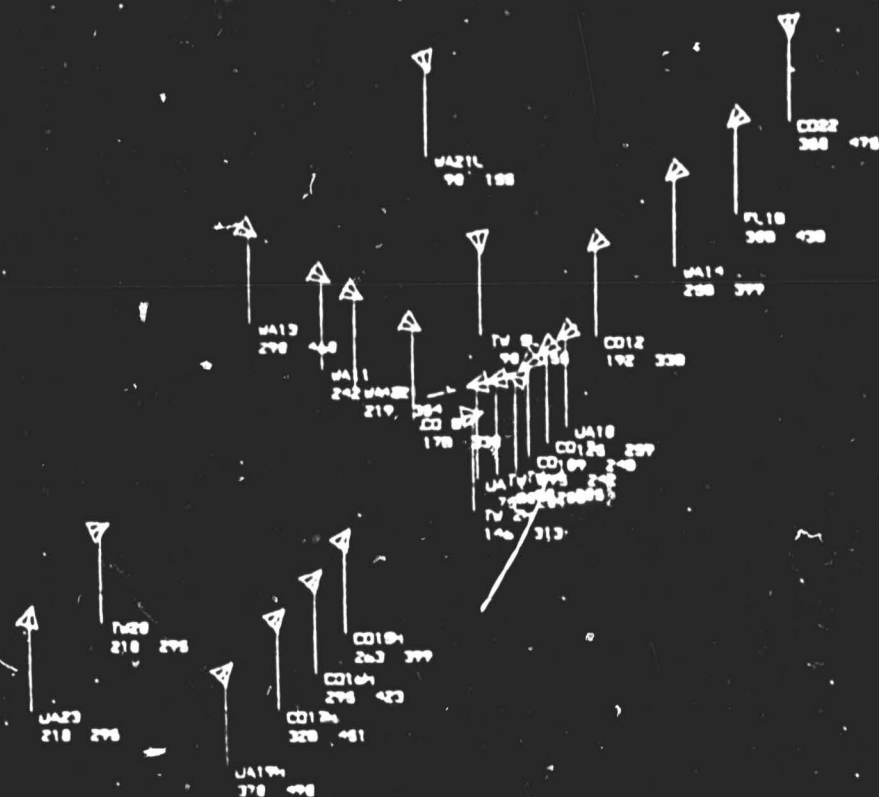
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SEED # - 1777 UPDATE INTERVAL = 8 ARRIVAL RATE = 45 MPS = 0

NEW ARRIVAL AT 8 --

ID =UA 1 ROUTE = 10 FCFS# = 1 NOMARR = 1504

#### TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
1	1	UA 1	1504	1804	300

NEW ARRIVAL AT 188 --

ID =TW 2H ROUTE = 2 FCFS# = 2 NOMARR = 1808

#### TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
1	1	UA 1	1504	1804	300
2	2	TW 2H	1808	1872	64

NEW ARRIVAL AT 256 --

ID =TW 3 ROUTE = 10 FCFS# = 2 NOMARR = 1752

#### TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
1	1	UA 1	1504	1804	300
2	2	TW 3	1752	1872	120
3	3	TW 2H	1808	1940	132

FINAL ASSIGNMENT FOR UA 1 (ROUTE = 10 FCFS# = 1)

CLOCK = 336 POSITION = 1 SCHED = 1804

DELAY(TOT) = 300 DELAY(ABS) = 0 DELAY(TOGO) = 300

NEW ARRIVAL AT 384 --

ID =TW 4 ROUTE = 10 FCFS# = 4 NOMARR = 1880

#### TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
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2	2	TW 3	1752	1872	120
3	3	TW 2H	1808	1940	132
4	4	TW 4	1880	2052	172

FINAL ASSIGNMENT FOR TW 3 (ROUTE = 10 FCFS# = 2)  
 CLOCK = 392 POSITION = 3 SCHED = 1872  
 DELAY(TOT) = 120 DELAY(ABS) = 0 DELAY(TOGO) = 120

NEW ARRIVAL AT 400 --  
 ID = TW 5L ROUTE = 14 FCFS# = 5 NOMARR = 2852

# TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
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3	3	TW 2H	1808	1940	132
4	4	TW 4	1880	2052	172
5	5	TW 5L	2852	2852	0

NEW ARRIVAL AT 428 --  
 ID = CO 6 ROUTE = 7 FCFS# = 4 NOMARR = 1852

# TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
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3	3	TW 2H	1808	1940	132
4	4	CO 6	1852	2056	204
5	5	TW 4	1880	2124	244
6	6	TW 5L	2852	2852	0

FINAL ASSIGNMENT FOR TW 2H(ROUTE = 2 FCFS# = 3)  
 CLOCK = 432 POSITION = 2 SCHED = 1940  
 DELAY(TOT) = 132 DELAY(ABS) = 0 DELAY(TOGO) = 132

FINAL ASSIGNMENT FOR CO 6 (ROUTE = 7 FCFS# = 4)  
 CLOCK = 464 POSITION = 6 SCHED = 2056  
 DELAY(TOT) = 204 DELAY(ABS) = 0 DELAY(TOGO) = 204

NEW ARRIVAL AT 520 --

ID =CO 7 ROUTE = 7 FCFS# = 6 NOMARR = 1944

TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
5	5	TW 4	1880	2124	244
6	6	CO 7	1944	2196	252
7	7	TW 5L	2852	2852	0

FINAL ASSIGNMENT FOR TW 4 (ROUTE = 10 FCFS# = 5)  
CLOCK = 528 POSITION = 4 SCHED = 2124  
DELAY(TOT) = 244 DELAY(ABS) = 60 DELAY(TOGO) = 184

NEW ARRIVAL AT 544 --  
ID =CO 8 ROUTE = 4 FCFS# = 7 NOMARR = 2176

TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
6	6	CO 7	1944	2196	252
7	7	CO 8	2176	2268	92
8	8	TW 5L	2852	2852	0

NEW ARRIVAL AT 636 --  
ID =WA 9 ROUTE = 4 FCFS# = 8 NOMARR = 2268

TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
6	6	CO 7	1944	2196	252
7	7	CO 8	2176	2268	92
8	8	WA 9	2268	2340	72
9	9	TW 5L	2852	2852	0

NEW ARRIVAL AT 680 --  
ID =UA10 ROUTE = 7 FCFS# = 7 NOMARR = 2104

TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
6	6	CO 7	1944	2196	252
7	7	UA10	2104	2268	164
8	8	CO 8	2176	2340	164
9	9	WA 9	2268	2412	144
10	10	TW 5L	2852	2852	0

FINAL ASSIGNMENT FOR CO 7 (ROUTE = 7 FCFS# = 6)  
 CLOCK = 688 POSITION = 7 SCHED = 2196  
 DELAY(TOT) = 252 DELAY(ABS) = 168 DELAY(TOGO) = 84

NEW ARRIVAL AT 728 ---  
 ID =WA11 ROUTE = 4 FCFS# = 10 NOMARR = 2360

#### TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
7	7	UA10	2104	2268	164
8	8	CO 8	2176	2340	164
9	9	WA 9	2268	2412	144
10	10	WA11	2360	2484	124
11	11	TW 5L	2852	2852	0

FINAL ASSIGNMENT FOR UA10 (ROUTE = 7 FCFS# = 7)  
 CLOCK = 760 POSITION = 10 SCHED = 2268  
 DELAY(TOT) = 164 DELAY(ABS) = 80 DELAY(TOGO) = 84

NEW ARRIVAL AT 800 ---  
 ID =CO12 ROUTE = 7 FCFS# = 9 NOMARR = 2224

#### TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
8	8	CO 8	2176	2340	164
9	9	CO12	2224	2412	188
10	10	WA 9	2268	2484	216
11	11	WA11	2360	2556	196
12	12	TW 5L	2852	2852	0

FINAL ASSIGNMENT FOR CO 8 (ROUTE = 4 FCFS# = 8)  
CLOCK = 808 POSITION = 8 SCHED = 2340  
DELAY(TOT) = 164 DELAY(ABS) = 0 DELAY(TOGO) = 164

FINAL ASSIGNMENT FOR CO12 (ROUTE = 7 FCFS# = 9)  
CLOCK = 848 POSITION = 12 SCHED = 2412  
DELAY(TOT) = 188 DELAY(ABS) = 48 DELAY(TOGO) = 140

NEW ARRIVAL AT 052 --  
ID =WA13 ROUTE = 4 FCFS# = 12 NOMARR = 2494

#### TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
10	10	WA 9	2268	2484	216
11	11	WA11	2360	2556	196
12	12	WA13	2484	2628	144
13	13	TW 5L	2852	2852	0

NEW ARRIVAL AT 936 --  
ID =WA14 ROUTE = 7 FCFS# = 12 NOMARR = 2360

#### TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
10	10	WA 9	2268	2484	216
11	11	WA11	2360	2556	196
12	12	WA14	2360	2628	268
13	13	WA13	2484	2700	216
14	14	TW 5L	2852	2852	0

FINAL ASSIGNMENT FOR WA 9 (ROUTE = 4 FCFS# = 10)  
CLOCK = 944 POSITION = 9 SCHED = 2484  
DELAY(TOT) = 216 DELAY(ABS) = 116 DELAY(TOGO) = 100

FINAL ASSIGNMENT FOR WA11 (ROUTE = 4 FCFS# = 11)  
CLOCK = 944 POSITION = 11 SCHED = 2556  
DELAY(TOT) = 196 DELAY(ABS) = 96 DELAY(TOGO) = 100

NEW ARRIVAL AT 1008 --  
ID =CO15H ROUTE = 2 FCFS# = 14 NOMARR = 2628



# TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
12	12	WA14	2360	2628	268
13	13	WA13	2484	2700	216
14	14	CO15H	2628	2768	140
15	15	TW 5L	2852	2936	84

FINAL ASSIGNMENT FOR WA14 (ROUTE = 7 FCFS# = 12):  
 CLOCK = 1064 POSITION = 14 SCHED = 2628  
 DELAY(TOT) = 268 DELAY(ABS) = 124 DELAY(TOGO) = 144

NEW ARRIVAL AT 1100 --  
 ID =CO16H ROUTE = 2 FCFS# = 15 NOMARR = 2720

# TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
13	13	WA13	2484	2700	216
14	14	CO15H	2628	2768	140
15	15	CO16H	2720	2860	140
16	16	TW 5L	2852	3028	176

NEW ARRIVAL AT 1192 --  
 ID =CO17H ROUTE = 2 FCFS# = 16 NOMARR = 2812

# TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
13	13	WA13	2484	2700	216
14	14	CO15H	2628	2768	140
15	15	CO16H	2720	2860	140
16	16	CO17H	2812	2952	140
17	17	TW 5L	2852	3120	268

FINAL ASSIGNMENT FOR WA13 (ROUTE = 4 FCFS# = 13):  
 CLOCK = 1208 POSITION = 13 SCHED = 2700  
 DELAY(TOT) = 216 DELAY(ABS) = 144 DELAY(TOGO) = 72

NEW ARRIVAL AT 1212 ---  
 ID = FL18 ROUTE = 7 FCFS# = 15 NOMARR = 2636

TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
14	14	CO15H	2628	2768	140
15	15	FL18	2636	2884	248
16	16	CO16H	2720	2952	232
17	17	CO17H	2812	3044	232
18	18	TW 5L	2852	3212	360

FINAL ASSIGNMENT FOR CO15H(ROUTE = 2 FCFS# = 14)  
 CLOCK = 1216 POSITION = 15 SCHED = 2768  
 DELAY(TOT) = 140 DELAY(ABS) = 0 DELAY(TOGO) = 140

FINAL ASSIGNMENT FOR FL18 (ROUTE = 7 FCFS# = 15)  
 CLOCK = 1304 POSITION = 18 SCHED = 2884  
 DELAY(TOT) = 248 DELAY(ABS) = 64 DELAY(TOGO) = 184

NEW ARRIVAL AT 1312 ---  
 ID = UA19H ROUTE = 2 FCFS# = 19 NOMARR = 2932

TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
16	16	CO16H	2720	2952	232
17	17	CO17H	2812	3044	232
18	18	TW 5L	2852	3212	360
19	19	UA19H	2932	3280	348

NEW ARRIVAL AT 1326 ---  
 ID = TW20 ROUTE = 12 FCFS# = 20 NOMARR = 3432

TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
16	16	CO16H	2720	2952	232

17	17	CO17H	2812	3044	232
18	18	TW 5L	2852	3212	360
19	19	UA19H	2932	3280	348
20	20	TW20	3432	3432	0

NEW ARRIVAL AT 1360 --  
ID =WA21L ROUTE = 14 FCFS# = 21 NOMARR = 3812

TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
16	16	CU16H	2720	2952	232
17	17	CO17H	2812	3044	232
18	18	TW 5L	2852	3212	360
19	19	UA19H	2932	3280	348
20	20	TW20	3432	3432	0
21	21	WA21L	3812	3812	0

FINAL ASSIGNMENT FOR CO16H(ROUTE = 2 FCFS# = 16):  
CLOCK = 1392 POSITION = 16 SCHED = 2952  
DELAY(TOT) = 232 DELAY(ABS) = 140 DELAY(TOGO) = 92

FINAL ASSIGNMENT FOR CO17H(ROUTE = 2 FCFS# = 17):  
CLOCK = 1432 POSITION = 17 SCHED = 3044  
DELAY(TOT) = 232 DELAY(ABS) = 180 DELAY(TOGO) = 52

FINAL ASSIGNMENT FOR TW 5L(ROUTE = 14 FCFS# = 18):  
CLOCK = 1512 POSITION = 5 SCHED = 3212  
DELAY(TOT) = 360 DELAY(ABS) = 0 DELAY(TOGO) = 360

NEW ARRIVAL AT 1540 --  
ID =CO22 ROUTE = 7 FCFS# = 20 NOMARR = 2964

TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
19	19	UA19H	2932	3280	348
20	20	CO22	2964	3396	432
21	21	TW20	3432	3464	32
22	22	WA21L	3812	3812	0

FINAL ASSIGNMENT FOR UA19H(ROUTE = 2 FCFS# = 19)  
 CLOCK = 1544 POSITION = 19 SCHED = 3280  
 DELAY(TOT) = 348 DELAY(ABS) = 204 DELAY(TOCC) = 144

NEW ARRIVAL AT 1656 --  
 ID =UA23 ROUTE = 12 FCFS# = 22 NOMARR = 3752

# TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
20	20	C022	2964	3396	432
21	21	TW20	3432	3464	32
22	22	UA23	3752	3752	C
23	23	WA21L	3812	3848	36

NEW ARRIVAL AT 1704 --  
 ID =UA24H ROUTE = 2 FCFS# = 21 NOMARR = 3324

# TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
20	20	C022	2964	3396	432
21	21	UA24H	3324	3464	140
22	22	TW20	3432	3596	164
23	23	UA23	3752	3752	0
24	24	WA21L	3812	3848	36

NEW ARRIVAL AT 1732 --  
 ID =C025 ROUTE = 4 FCFS# = 22 NOMARR = 3364

# TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
20	20	C022	2964	3396	432
21	21	UA24H	3324	3464	140
22	22	C025	3364	3580	216
23	23	TW20	3432	3648	216
24	24	UA23	3752	3752	0
25	25	WA21L	3812	3848	36

NEW ARRIVAL AT 1888 --  
 ID = TW26 ROUTE = 24 FCFS# = 24 NOMARR = 3488

TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
20	20	C022	2964	3396	432
21	21	UA24H	3324	3464	140
22	22	C025	3364	3580	216
23	23	TW20	3432	3648	216
24	24	TW26	3488	3720	232
25	25	UA23	3752	3788	36
26	26	WA21L	3812	3884	72

NEW ARRIVAL AT 1888 --  
 ID = FL27 ROUTE = 7 FCFS# = 21 NOMARR = 3312

TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
20	20	C022	2964	3396	432
21	21	FL27	3312	3468	156
22	22	UA24H	3324	3536	212
23	23	C025	3364	3652	288
24	24	TW20	3432	3720	288
25	25	TW26	3488	3792	304
26	26	UA23	3752	3860	108
27	27	WA21L	3812	3956	144

FINAL ASSIGNMENT FOR C022 (ROUTE = 7 FCFS# = 20)  
 CLOCK = 1896 POSITION = 22 SCHED = 3396  
 DELAY(TOT) = 432 DELAY(ABS) = 0 DELAY(TOGO) = 432

FINAL ASSIGNMENT FOR FL27 (ROUTE = 7 FCFS# = 21)  
 CLOCK = 1904 POSITION = 27 SCHED = 3468  
 DELAY(TOT) = 156 DELAY(ABS) = 0 DELAY(TOGO) = 156

FINAL ASSIGNMENT FOR UA24H (ROUTE = 2 FCFS# = 22)  
 CLOCK = 1944 POSITION = 24 SCHED = 3536  
 DELAY(TOT) = 112 DELAY(ABS) = 48 DELAY(TOGO) = 164

NEW ARRIVAL AT 1648 --  
 ID = FL28 ROUTE = 4 FCFS# = 26 NOMARR = 3580

# TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
23	23	C025	3364	3652	288
24	24	TW27	3432	3720	288
25	25	TW26	3488	3792	304
26	26	FL28	3580	3864	284
27	27	UA23	3752	3932	180
28	28	WA21L	3812	4028	216

FINAL ASSIGNMENT FOR C025 (ROUTE = 4 FCFS# = 23)  
 CLOCK = 2016 POSITION = 25 SCHED = 3652  
 DELAY(TOT) = 288 DELAY(ABS) = 0 DELAY(TOGO) = 288

NEW ARRIVAL AT 2044 --  
 ID = TW29H ROUTE = 2 FCFS# = 27 NOMARR = 3664

# TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
24	24	TW20	3432	3720	288
25	25	TW26	3488	3792	304
26	26	FL28	3580	3864	284
27	27	TW29H	3664	3932	268
28	28	UA23	3752	4064	312
29	29	WA21L	3812	4160	348

NEW ARRIVAL AT 2652 ---  
 ID = WA30L ROUTE = 14 FCFS# = 30 NOMARR = 4504

# TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
24	24	TW20	3432	3720	288
25	25	TW26	3488	3792	304

26	26	FL28	3580	3864	204
27	27	TW29H	3664	3932	268
28	28	UA23	3752	4064	312
29	29	WA21L	3812	4160	348
30	30	WA30L	4504	4504	0

FINAL ASSIGNMENT FOR TW20 (ROUTE = 12 FCFS# = 24):  
 CLOCK = 2072 POSITION = 20 SCHED = 3720  
 DELAY(TOT) = 288 DELAY(ABS) = 0 DELAY(TOGO) = 288

FINAL ASSIGNMENT FOR TW26 (ROUTE = 4 FCFS# = 25):  
 CLOCK = 2160 POSITION = 26 SCHED = 3792  
 DELAY(TOT) = 304 DELAY(ABS) = 92 DELAY(TOGO) = 212

FINAL ASSIGNMENT FOR FL28 (ROUTE = 4 FCFS# = 26):  
 CLOCK = 2248 POSITION = 28 SCHED = 3934  
 DELAY(TOT) = 284 DELAY(ABS) = 160 DELAY(TOGO) = 124

FINAL ASSIGNMENT FOR TW29H (ROUTE = 2 FCFS# = 27):  
 CLOCK = 2336 POSITION = 29 SCHED = 3932  
 DELAY(TOT) = 268 DELAY(ABS) = 0 DELAY(TOGO) = 268

FINAL ASSIGNMENT FOR UA23 (ROUTE = 12 FCFS# = 28):  
 CLOCK = 2392 POSITION = 23 SCHED = 4064  
 DELAY(TOT) = 312 DELAY(ABS) = 36 DELAY(TOGO) = 276

FINAL ASSIGNMENT FOR WA21L (ROUTE = 14 FCFS# = 29):  
 CLOCK = 2912 POSITION = 21 SCHED = 4160  
 DELAY(TOT) = 248 DELAY(ABS) = 0 DELAY(TOGO) = 348

FINAL ASSIGNMENT FOR WA30L (ROUTE = 14 FCFS# = 30):  
 CLOCK = 3608 POSITION = 30 SCHED = 4504  
 DELAY(TOT) = 0 DELAY(ABS) = 0 DELAY(TOGO) = 0

LAND#	ENT#	FCFS#	ID	ROUTE	ENTER	NOMARR	SCHED	DELAY	TYTOGO	DELABS	DEL2GO
1	1	1	UA 1	10	8	1504	1804	100	1468	0	300
2	3	2	TW 3	10	256	1752	1872	120	1480	0	120
3	2	3	TW 2H	2	188	1808	1940	132	1508	0	132
4	6	4	CO 6	7	428	1852	2056	204	1592	0	204
5	4	5	TW 4	10	384	1880	2124	244	1596	60	184
6	7	6	CO 7	7	520	1744	2196	252	1508	168	84
7	10	7	UA10	7	680	2104	2268	164	1508	80	84
8	8	8	CO 8	4	544	2176	2340	164	1532	0	164
9	12	9	CO12	7	800	2224	2412	188	1564	48	140
10	9	10	WA 9	4	636	2268	2484	216	1540	116	100
11	11	11	WA11	4	728	2360	2556	196	1612	96	100
12	14	12	WA14	7	936	2360	2628	268	1564	124	144
13	13	13	WA13	4	952	2484	2700	216	1492	14	72
14	15	14	CO15H	2	1008	2628	2768	140	1552	0	140
15	18	15	FL18	7	1212	2636	2884	248	1580	64	184
16	16	16	CO16H	2	1100	2720	2952	232	1560	140	92
17	17	17	CO17H	2	1192	2812	3044	232	1612	180	52
18	5	18	TW 5L	14	400	2852	3212	360	1700	0	360
19	19	19	UA19H	2	1312	2932	3280	348	1736	204	144
20	22	20	CO22	7	1540	2964	3396	432	1500	0	432
21	27	21	FL27	7	1888	3312	3468	156	1564	0	156
22	24	22	UA24H	2	1704	3324	3536	212	1592	48	164
23	25	23	CO25	4	1732	3364	3652	288	1636	0	288
24	20	24	TW20	12	1336	3432	3720	288	1648	0	288
25	26	25	TW26	4	1856	3488	3792	304	1632	92	212
26	28	26	FL28	4	1948	3580	3864	284	1616	160	124
27	29	27	TW29H	2	2044	3664	3932	268	1596	0	268
28	23	28	UA23	12	1656	3752	4064	312	1672	36	276
29	21	29	WA21L	14	1360	3812	4160	348	1248	0	348
30	30	30	WA30L	14	2052	4504	4504	0	896	0	0
TOTAL DELAY = 7116											

MAXIMUM NUMBER OF POSITION SHIFTS = 0

EFFECTIVE ARRIVAL RATE INTO THE TERMINAL AREA = 52.84 PER HOUR

AVERAGE DELAY PER AIRCRAFT = 237.20 SECONDS



SEED # = 1777 UPDATE INTERVAL = 8 ARRIVAL RATE = 45 MPS = 4

NEW ARRIVAL AT 0 --  
ID =UA 1 ROUTE = 10 FCFS# = 1 NOMARR = 1504

TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
1	1	UA 1	1504	1804	300

NEW ARRIVAL AT 188 --  
ID =TW 2H ROUTE = 2 FCFS# = 2 NOMARR = 1808

TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
1	1	UA 1	1504	1804	300
2	2	TW 2H	1808	1872	64

NEW ARRIVAL AT 256 --  
ID =TW 3 ROUTE = 10 FCFS# = 2 NOMARR = 1752

TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
1	1	UA 1	1504	1804	300
2	2	TW 3	1752	1872	120
3	3	TW 2H	1808	1940	132

NEW ARRIVAL AT 384 --  
ID =TW 4 ROUTE = 10 FCFS# = 4 NOMARR = 1880

TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
1	1	UA 1	1504	1804	300

2	2	TW 3	1752	1872	120
3	3	TW 2H	1808	1940	132
4	4	TW 4	1880	2052	172

NEW ARRIVAL AT 400 --  
ID =TW 5L ROUTE = 14 FCFS# = 5 NOMARR = 2852

# TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
1	1	UA 1	1504	1804	300
2	2	TW 3	1752	1872	120
3	4	TW 4	1880	1940	60
4	3	TW 2H	1808	2008	200
5	5	TW 5L	2852	2852	0

NEW ARRIVAL AT 428 --  
ID =CO 6 ROUTE = 7 FCFS# = 4 NOMARR = 1852

# TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
1	1	UA 1	1504	1804	300
2	2	TW 3	1752	1872	120
3	5	TW 4	1880	1940	60
4	4	CU 6	1852	2012	160
5	3	TW 2H	1808	2080	277
6	6	TW 5L	2852	2852	0

NEW ARRIVAL AT 520 --  
ID =CO 7 ROUTE = 7 FCFS# = 6 NOMARR = 1944

# TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
1	1	UA 1	1504	1804	300
2	2	TW 3	1752	1872	120
3	5	TW 4	1880	1940	60
4	4	CU 6	1852	2012	160

5	6	CO 7	1944	2084	140
6	3	TW 2H	1808	2152	344
7	7	TW 5L	2852	2852	0

FINAL ASSIGNMENT FOR UA 1 (ROUTE = 10 FCFS# = 1)  
CLOCK = 528 POSITION = 1 SCHED = 1804  
DELAY(TOT) = 300 DELAY(ABS) = 0 DELAY(TOCC) = 300

NEW ARRIVAL AT 544 --  
ID =CO 8 ROUTE = 4 FCFS# = 7 NOMARR = 2176

TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
2	2	TW 3	1752	1872	120
3	5	TW 4	1880	1940	60
4	4	CO 6	1852	2012	160
5	6	CO 7	1944	2084	140
6	3	TW 2H	1808	2152	344
7	7	CO 8	2176	2268	92
8	8	TW 5L	2852	2852	0

NEW ARRIVAL AT 636 --  
ID =WA 9 ROUTE = 4 FCFS# = 8 NOMARR = 2268

TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
2	2	TW 3	1752	1872	120
3	5	TW 4	1880	1940	60
4	4	CO 6	1852	2012	160
5	6	CO 7	1944	2084	140
6	3	TW 2H	1808	2152	344
7	7	CO 8	2176	2268	92
8	8	WA 9	2268	2340	72
9	9	TW 5L	2852	2852	0

NEW ARRIVAL AT 680 --  
ID =UA10 ROUTE = 7 FCFS# = 7 NOMARR = 2104

# TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
2	2	TW 3	1752	1872	120
3	5	TW 4	1880	1940	60
4	4	CO 6	1852	2012	160
5	6	CO 7	1944	2084	140
6	7	UA10	2104	2156	52
7	3	TW 2H	1808	2224	416
8	8	CO 8	2176	2340	164
9	9	WA 9	2268	2412	144
10	10	TW 5L	2852	2852	0

FINAL ASSIGNMENT FOR TW 3 (ROUTE = 10 FCFS# = 2)  
 CLOCK = 688 POSITION = 3 SCHED = 1872  
 DELAY(TOT) = 120 DELAY(ABS) = 0 DELAY(TOGO) = 120

NEW ARRIVAL AT 728 --  
 ID =WA11 ROUTE = 4 FCFS# = 10 NOMARR = 2360

# TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
3	5	TW 4	1880	1940	60
4	4	CO 6	1852	2012	160
5	6	CO 7	1944	2084	140
6	7	UA10	2104	2156	52
7	3	TW 2H	1808	2224	416
8	8	CO 8	2176	2340	164
9	9	UA 9	2268	2412	144
10	10	WA11	2360	2484	124
11	11	TW 5L	2852	2852	0

FINAL ASSIGNMENT FOR TW 4 (ROUTE = 10 FCFS# = 5)  
 CLOCK = 760 POSITION = 4 SCHED = 1940  
 DELAY(TOT) = 60 DELAY(ABS) = 12 DELAY(TOGO) = 48

NEW ARRIVAL AT 800 --  
 ID =CO12 ROUTE = 7 FCFS# = 9 NOMARR = 2224

# TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
4	4	CO 6	1852	2012	160
5	6	CO 7	1944	2084	140
6	7	UA10	2104	2156	52
7	3	TW 2H	1808	2224	416
8	8	CO 8	2176	2340	164
9	9	CO12	2224	2412	188
10	10	WA 9	2268	2484	216
11	11	WA11	2360	2556	196
12	12	TW 5L	2852	2852	0

FINAL ASSIGNMENT FOR CO 6 (ROUTE = 7 FCFS# = 4)  
 CLOCK = 808 POSITION = 6 SCHED = 2012  
 DELAY(TOT) = 160 DELAY(ABS) = 0 DELAY(TOGO) = 160

FINAL ASSIGNMENT FOR CO 7 (ROUTE = 7 FCFS# = 6)  
 CLOCK = 848 POSITION = 7 SCHED = 2084  
 DELAY(TOT) = 140 DELAY(ABS) = 20 DELAY(TOGO) = 120

NEW ARRIVAL AT 852 --  
 ID =WA13 ROUTE = 4 FCFS# = 12 NOMARR = 2484

# TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
6	7	UA10	2104	2156	52
7	3	TW 2H	1808	2224	416
8	8	CO 8	2176	2340	164
9	9	CO12	2224	2412	188
10	10	WA 9	2268	2484	216
11	11	WA11	2360	2556	196
12	12	WA13	2484	2628	144
13	13	TW 5L	2852	2852	0

FINAL ASSIGNMENT FOR TW 2H(ROUTE = 2 FCFS# = 3)  
 CLOCK = 912 POSITION = 2 SCHED = 2224  
 DELAY(TOT) = 416 DELAY(ABS) = 0 DELAY(TOGO) = 416

NEW ARRIVAL AT 936 --  
 ID =WA14 ROUTE = 7 FCFS# = 12 NOMARR = 2360

# TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
6	7	UA10	2104	2156	52
8	8	CO 8	2176	2340	164
9	9	CO12	2224	2412	188
10	10	WA 9	2268	2484	216
11	11	WA11	2360	2556	196
12	12	WA14	2360	2628	268
13	13	WA13	2484	2700	216
14	14	TW 5L	2852	2852	0

FINAL ASSIGNMENT FOR UA10 (ROUTE = 7 FCFS# = 7):  
 CLOCK = 944 POSITION = 10 SCHED = 2156  
 DELAY(TOT) = 52 DELAY(ABS) = 28 DELAY(TOGO) = 24

NEW ARRIVAL AT 1008 --  
 ID =CO15H ROUTE = 2 FCFS# = 14 NOMARR = 2628

# TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
8	8	CU 8	2176	2340	164
9	9	CU12	2224	2412	188
10	10	WA 9	2268	2484	216
11	11	WA11	2360	2556	196
12	12	WA14	2360	2628	268
13	13	CU14H	2628	2696	68
14	14	WA13	2484	2812	328
15	15	TW 5L	2852	2908	56

FINAL ASSIGNMENT FOR CO 8 (ROUTE = 4 FCFS# = 8):  
 CLOCK = 1064 POSITION = 8 SCHED = 2340  
 DELAY(TOT) = 164 DELAY(ABS) = 0 DELAY(TOGO) = 164

NEW ARRIVAL AT 1100 --  
 ID =CO16H ROUTE = 2 FCFS# = 15 NOMARR = 272

# TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
9	9	C012	2224	2412	188
10	10	WA 9	2268	2484	216
11	11	WA11	2360	2556	196
12	12	WA14	2360	2628	268
13	14	C015H	2628	2696	68
14	15	C016H	2720	2788	68
15	13	WA13	2484	2904	420
16	16	TW 5L	2852	3000	148

NEW ARRIVAL AT 1192 --  
ID =C017H ROUTE = 2 FCFS# = 16 NOMARR = 2812

# TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
9	9	C012	2224	2412	188
10	10	WA 9	2268	2494	216
11	11	WA11	2360	2556	196
12	12	WA14	2360	2628	268
13	14	C015H	2628	2696	68
14	15	C016H	2720	2788	68
15	16	C017H	2812	2880	68
16	13	WA13	2484	2996	512
17	17	TW 5L	2852	3092	240

FINAL ASSIGNMENT FOR C012 (ROUTE = 7 FCFS# = 9):  
CLOCK = 1208 POSITION = 12 SCHED = 2412  
DELAY(TOT) = 188 DELAY(ABS) = 4 DELAY(TOGO) = 184

NEW ARRIVAL AT 1212 --  
ID =FL18 ROUTE = 7 FCFS# = 15 NOMARR = 2636

# TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
10	10	WA 9	2268	2484	216
11	11	WA11	2360	2556	196
12	12	WA14	2360	2628	268
13	13	WA13	2484	2700	216

14	14	CO15H	2628	2768	140
15	16	CO16H	2720	2860	140
16	17	CO17H	2812	2952	140
17	15	FL18	2636	3068	432
18	18	TW 5L	2852	3164	312

FINAL ASSIGNMENT FOR WA 9 (ROUTE = 4 FCFS# = 10)  
 CLOCK = 1216 POSITION = 9 SCHED = 2484  
 DELAY(TOT) = 216 DELAY(ABS) = 132 DELAY(TOGO) = 84

FINAL ASSIGNMENT FOR WA11 (ROUTE = 4 FCFS# = 11)  
 CLOCK = 1304 POSITION = 11 SCHED = 2556  
 DELAY(TOT) = 196 DELAY(ABS) = 196 DELAY(TOGO) = 0

NEW ARRIVAL AT 1312 --  
 ID =UA19H ROUTE = 2 FCFS# = 19 NOMARR = 2932

# TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
12	12	WA14	2360	2628	268
13	13	WA13	2484	2700	216
14	15	FL18	2636	2772	136
15	18	TW 5L	2852	2868	16
16	14	CO15H	2628	2936	308
17	16	CO16H	2720	3028	308
18	17	CO17H	2812	3120	308
19	19	UA19H	2932	3212	280

NEW ARRIVAL AT 1326 --  
 ID =TW20 ROUTE = 12 FCFS# = 20 NOMARR = 3432

# TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
12	12	WA14	2360	2628	268
13	13	WA13	2484	2700	216
14	15	FL18	2636	2772	136
15	18	TW 5L	2852	2868	16
16	14	CO15H	2628	2936	308
17	16	CO16H	2720	3028	308



18	17	CO17H	2812	3120	308
19	19	UA19H	2932	3212	280
20	20	TU20	3432	3432	0

NEW ARRIVAL AT 1300 ---  
ID =WA21L ROUTE = 14 FCFS# = 21 NOMARR = 3812

TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
12	12	WA14	2360	2628	268
13	13	WA13	2484	2700	216
14	15	FL18	2636	2772	136
15	18	TW 5L	2852	2868	16
16	14	CO15H	2628	2936	308
17	16	CO16H	2720	3028	308
18	17	CO17H	2812	3120	308
19	19	UA19H	2932	3212	280
20	20	TW20	3432	3432	0
21	21	WA21L	3812	3812	0

FINAL ASSIGNMENT FOR WA14 (ROUTE = 7 FCFS# = 12):  
CLOCK = 1392 POSITION = 14 SCHED = 2628  
DELAY(TOT) = 268 DELAY(ABS) = 124 DELAY(TOGO) = 144

FINAL ASSIGNMENT FOR WA13 (ROUTE = 4 FCFS# = 13):  
CLOCK = 1432 POSITION = 13 SCHED = 2700  
DELAY(TOT) = 216 DELAY(ABS) = 144 DELAY(TOGO) = 72

FINAL ASSIGNMENT FOR FL18 (ROUTE = 7 FCFS# = 15):  
CLOCK = 1512 POSITION = 18 SCHED = 2772  
DELAY(TOT) = 136 DELAY(ABS) = 40 DELAY(TOGO) = 96

NEW ARRIVAL AT 1340 ---  
ID =CO22 ROUTE = 7 FCFS# = 20 NOMARR = 2964

TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
15	18	TW 5L	2852	2868	16
16	14	CO15H	2628	2936	308

17	16	CO16H	2720	3028	308
18	17	CO17H	2812	3120	308
19	19	UA19H	2932	3212	280
20	20	CO22	2964	3328	364
21	21	TW20	3432	3432	0
22	22	WA21L	3812	3812	0

FINAL ASSIGNMENT FOR TW 5L(ROUTE = 14 FCFS# = 18):

CLOCK = 1544 POSITION = 5 SCHED = 2868

DELAY(TOT) = 16 DELAY(ABS) = 0 DELAY(TOGO) = 16

NEW ARRIVAL AT 1656 --

ID =UA23 ROUTE = 12 FCFS# = 22 NOMARR = 3752

#### TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
16	14	CO15H	2628	2936	308
17	16	CO16H	2720	3028	308
18	17	CO17H	2812	3120	308
19	19	UA19H	2932	3212	280
20	20	CO22	2964	3328	364
21	21	TW20	3432	3432	0
22	22	UA23	3752	3752	0
23	23	WA21L	3812	3848	36

NEW ARRIVAL AT 1704 --

ID =UA24H ROUTE = 2 FCFS# = 21 NOMARR = 3324

#### TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
16	14	CO15H	2628	2936	308
17	16	CO16H	2720	3028	308
18	17	CO17H	2812	3120	308
19	19	UA19H	2932	3212	280
20	20	CO22	2964	3328	364
21	21	UA24H	3324	3396	72
22	22	TW20	3432	3528	96
23	23	UA23	3752	3752	0
24	24	WA21L	3812	3848	36

FINAL ASSIGNMENT FOR C015H(ROUTE = 2 FCFS# = 14):  
 CLOCK = 1728 POSITION = 15 SCHED = 2936  
 DELAY(TOT) = 308 DELAY(ABS) = 0 DELAY(TOGO) = 308

NEW ARRIVAL AT 1732 ---  
 ID =C025 ROUTE = 4 FCFS# = 22 NOMARR = 3364

# TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
17	16	C016H	2720	3028	308
18	17	C017H	2812	3120	308
19	19	UA19H	2932	3212	280
20	20	C022	2964	3328	364
21	22	C025	3364	3400	36
22	23	TW20	3432	3468	36
23	21	UA24H	3324	3536	212
24	24	UA23	3752	3752	0
25	25	WA21L	3812	3848	36

NEW ARRIVAL AT 1056 ---  
 ID =TW26 ROUTE = 4 FCFS# = 24 NOMARR = 3488

# TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
17	16	C016H	2720	3028	308
18	17	C017H	2812	3120	308
19	19	UA19H	2932	3212	280
20	20	C022	2964	3328	364
21	22	C025	3364	3400	36
22	23	TW20	3432	3468	36
23	24	TW26	3488	3540	52
24	21	UA24H	3324	3608	284
25	25	UA23	3752	3752	0
26	26	WA21L	3812	3848	36

NEW ARRIVAL AT 1888 ---  
 ID =FL27 ROUTE = 7 FCFS# = 21 NOMARR = 3312

# TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
17	16	CO16H	2720	3028	308
18	17	CO17H	2812	3120	308
19	19	UA19H	2932	3212	280
20	20	CO22	2964	3328	364
21	21	FL27	3312	3400	88
22	24	TW20	3432	3468	36
23	23	CO25	3364	3540	176
24	22	UA24H	3324	3608	124
25	25	TW26	3488	3724	236
26	26	JA23	3752	3792	40
27	27	WA21L	3812	3888	76

FINAL ASSIGNMENT FOR CO16H(ROUTE = 2 FCFS# = 16):  
 CLOCK = 1904 POSITION = 16 SCHED = 3028  
 DELAY(TOT) = 308 DELAY(ABS) = 176 DELAY(TOGO) = 132

FINAL ASSIGNMENT FOR CO17H(ROUTE = 2 FCFS# = 17):  
 CLOCK = 1944 POSITION = 17 SCHED = 3120  
 DELAY(TOT) = 308 DELAY(ABS) = 216 DELAY(TOGO) = 92

NEW ARRIVAL AT 1948 --  
 ID = FL28 ROUTE = 4 FCFS# = 26 NOMARR = 3580

# TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
19	19	UA19H	2932	3212	280
20	20	CO22	2964	3328	364
21	21	FL27	3312	3400	88
22	24	TW20	3432	3468	36
23	23	CO25	3364	3540	176
24	25	TW26	3488	3612	124
25	22	UA24H	3324	3680	356
26	26	FL28	3580	3796	216
27	27	UA23	3752	3864	112
28	28	WA21L	3812	3960	148

FINAL ASSIGNMENT FOR UA19H(ROUTE = 2 FCFS# = 19):

CLOCK = 2016 POSITION = 19 SCHED = 3212  
DELAY(TOT) = 280 DELAY(ABS) = 260 DELAY(TOGO) = 20

NEW ARRIVAL AT 2044 --  
ID =TW29H ROUTE = 2 FCFS# = 27 NOMARR = 3664

TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
20	20	C022	2964	3328	364
21	21	FL27	3312	3400	88
22	24	TW20	3432	3468	36
23	23	C025	3364	3540	176
24	25	TW26	3488	3612	124
25	22	UA24H	3324	3680	356
26	27	TW29H	3664	3772	108
27	26	FL28	3580	3888	308
28	28	UA23	3752	3956	204
29	29	WA21L	3812	4052	240

NEW ARRIVAL AT 2052 --  
ID =WA30L ROUTE = 14 FCFS# = 30 NOMARR = 4504

TENTATIVE AIRCRAFT ASSIGNMENTS

LAND#	FCFS#	ID	NOMARR	SCHED	DELAY
20	20	C022	2964	3328	364
21	21	FL27	3312	3400	88
22	24	TW20	3432	3468	36
23	23	C025	3364	3540	176
24	25	TW26	3488	3612	124
25	26	FL28	3580	3684	104
26	22	UA24H	3324	3752	428
27	27	TW29H	3664	3844	180
28	28	UA23	3752	3976	224
29	29	WA21L	3812	4072	260
30	30	WA30L	4504	4504	0

FINAL ASSIGNMENT FOR C022 (ROUTE = 7 FCFS# = 20)  
CLOCK = 2064 POSITION = 22 SCHED = 3328  
DELAY(TOT) = 364 DELAY(ABS) = 0 DELAY(TOGO) = 364

FINAL ASSIGNMENT FOR FL27 (ROUTE = 7 FCFS# = 21)  
 CLOCK = 2160 POSITION = 27 SCHED = 3400  
 DELAY(TOT) = 88 DELAY(ABS) = 0 DELAY(TOGO) = 88

FINAL ASSIGNMENT FOR TW20 (ROUTE = 12 FCFS# = 24)  
 CLOCK = 2248 POSITION = 20 SCHED = 3468  
 DELAY(TOT) = 36 DELAY(ABS) = 0 DELAY(TOGO) = 36

FINAL ASSIGNMENT FOR C025 (ROUTE = 4 FCFS# = 23)  
 CLOCK = 2336 POSITION = 25 SCHED = 3540  
 DELAY(TOT) = 176 DELAY(ABS) = 0 DELAY(TOGO) = 176

FINAL ASSIGNMENT FOR TW26 (ROUTE = 4 FCFS# = 25)  
 CLOCK = 2392 POSITION = 26 SCHED = 3612  
 DELAY(TOT) = 124 DELAY(ABS) = 4 DELAY(TOGO) = 120

FINAL ASSIGNMENT FOR VA24H(ROUTE = 2 FCFS# = 22)  
 CLOCK = 2424 POSITION = 24 SCHED = 3752  
 DELAY(TOT) = 428 DELAY(ABS) = 0 DELAY(TOGO) = 428

FINAL ASSIGNMENT FOR FL28 (ROUTE = 4 FCFS# = 26)  
 CLOCK = 2784 POSITION = 28 SCHED = 3684  
 DELAY(TOT) = 104 DELAY(ABS) = 104 DELAY(TOGO) = 0

FINAL ASSIGNMENT FOR VA23 (ROUTE = 12 FCFS# = 28)  
 CLOCK = 2856 POSITION = 23 SCHED = 3976  
 DELAY(TOT) = 224 DELAY(ABS) = 0 DELAY(TOGO) = 224

FINAL ASSIGNMENT FOR WA21L(ROUTE = 14 FCFS# = 29)  
 CLOCK = 2912 POSITION = 21 SCHED = 4072  
 DELAY(TOT) = 260 DELAY(ABS) = 0 DELAY(TOGO) = 260

FINAL ASSIGNMENT FOR TW29H(ROUTE = 2 FCFS# = 27)  
 CLOCK = 2944 POSITION = 29 SCHED = 3844  
 DELAY(TOT) = 180 DELAY(ABS) = 180 DELAY(TOGO) = 0

FINAL ASSIGNMENT FOR WA30L(ROUTE = 14 FCFS# = 30)  
 CLOCK = 3608 POSITION = 30 SCHED = 4504  
 DELAY(TOT) = 0 DELAY(ABS) = 0 DELAY(TOGO) = 0

LAND#	ENT#	FCFS#	ID	ROUTE	ENTER	NOMARR	SCHED	DELAY	TYTOGO	DELABS	DEL2GO
1	1	1	UA 1	10	8	1504	1804	100	1276	0	300
2	3	2	TW 3	10	256	1752	1872	120	1184	0	120
3	4	5	TW 4	10	384	1880	1940	60	1180	12	48
4	6	4	CO 6	7	428	1852	2012	160	1204	0	160
5	7	6	CO 7	7	520	1944	2084	140	1236	20	120
6	10	7	UA10	7	680	2104	2156	52	1212	28	24
7	2	3	TW 2H	2	188	1908	2224	416	1312	0	416
8	8	8	CO 8	4	544	2176	2340	164	1276	0	164
9	12	9	CO12	7	800	2224	2412	188	1204	4	184
10	9	10	WA 9	4	636	2268	2484	216	1268	132	84
11	11	11	WA11	4	728	2360	2556	196	1252	196	0
12	14	12	WA14	7	936	2360	2628	268	1236	124	144
13	13	13	WA13	4	852	2484	2700	216	1268	144	72
14	18	15	FL18	7	1212	2636	2772	136	1260	40	96
15	5	18	TW 5L	14	400	2852	2868	16	1324	0	16
16	15	14	CO15H	2	1008	2628	2936	308	1208	0	308
17	16	16	CO16H	2	1100	2720	3028	308	1124	176	132
18	17	17	CO17H	2	1192	2812	3120	308	1176	216	92
19	19	19	UA19H	2	1312	2932	3212	280	1196	260	20
20	22	20	CO22	7	1540	2964	3328	364	1264	0	364
21	27	21	FL27	7	1888	3312	3400	88	1240	0	88
22	20	24	TW20	12	1336	3432	3468	36	1220	0	36
23	25	23	CO25	4	1732	3364	3540	176	1204	0	176
24	26	25	TW26	4	1856	3488	3612	124	1220	4	120
25	28	26	FL28	4	1948	3580	3684	104	900	104	0
26	24	22	UA24H	2	1704	3324	3752	428	1328	0	428
27	29	27	TW29H	2	2044	3664	3844	180	900	180	0
28	23	28	UA23	12	1656	3752	3976	224	1120	0	224
29	21	27	WA21L	14	1360	3812	4072	260	1160	0	260
30	30	30	WA30L	14	2052	4504	4504	0	896	0	0
TOTAL DELAY = 5836											

MAXIMUM NUMBER OF POSITION SHIFTS = 4  
 EFFECTIVE ARRIVAL RATE INTO THE TERMINAL AREA = 52.84 PER HOUR  
 AVERAGE DELAY PER AIRCRAFT = 194.53 SECONDS

```

C
C* THIS IS THE MAIN PROGRAM
C
      IMPLICIT INTEGER(A-Z)
      COMMON/SETUP1/UPDATE, DELTA, ARRATE, CLOCK
      CALL SPINIT
      CALL SETUPR

C
C* INITIALIZE E&S
C
      CALL PSINIT(3,0)
      CALL CHAR(1,1,0)
      CALL PUSH
      CALL STARTC

C
C* DISPLAY NEW E&S FRAME.
C
C 2      CALL BLDESX
      CALL NUFRAM
      CALL STARTC

C
C* CHECK FOR ANY OUTPUT
C
      CALL GUITR

C
C* CHECK FOR THE END OF THE RUN
C
      IF(DELTA.EQ.-9999)GOTO 999

C
C* UPDATE ALL DATA
C
100      CALL FRMSGX
      GO TO 2
999      CONTINUE
      REWIND 6
      CALL SCOPE(0)
      CALL NUFRAM
      STOP
      END

```



## SUBROUTINE SPINIT

```

C
C* SET UP THE DIRECT ACCESS FILES OF THE SIX AIRCRAFT TYPES
C
      OPEN(UNIT=2, NAME='DC10.2', TYPE='UNKNOWN',
1 ACCESS='DIRECT', RECORDSIZE=3, ASSOCIATEVARIABLE=IREC2)
      OPEN(UNIT=34, NAME='B737.4', TYPE='UNKNOWN',
1 ACCESS='DIRECT', RECORDSIZE=3, ASSOCIATEVARIABLE=IREC34)
      OPEN(UNIT=22, NAME='B727.7', TYPE='UNKNOWN',
1 ACCESS='DIRECT', RECORDSIZE=3, ASSOCIATEVARIABLE=IREC22)
      OPEN(UNIT=59, NAME='DHC6.14', TYPE='UNKNOWN',
1 ACCESS='DIRECT', RECORDSIZE=3, ASSOCIATEVARIABLE=IREC59)
      OPEN(UNIT=72, NAME='CV58.12', TYPE='UNKNOWN',
1 ACCESS='DIRECT', RECORDSIZE=3, ASSOCIATEVARIABLE=IREC72)
      OPEN(UNIT=85, NAME='DC9.10', TYPE='UNKNOWN',
1 ACCESS='DIRECT', RECORDSIZE=3, ASSOCIATEVARIABLE=IREC85)
      RETURN
      END

```

```

C
C
C* THIS FUNCTION IS NEEDED TO ACCOMODATE MORE THAN 100 AIRCRAFT
C
C

```

```

      INTEGER FUNCTION ROW(N1)
      ROW=MOD(N1+100,100)
      IF (ROW EQ 0) ROW=100
      RETURN
      END

```

```

C
C      THIS IS A SUBROUTINE TO SET UPDATING PARAMETERS
C      FOR A STAND-ALONE RUN
C
C      SUBROUTINE SETUPR
C
C      IMPLICIT INTEGER (A-Z)
C
C      COMMON/SETUP1/UPDATE, DELTA, ARRATE, CLOCK
C
C      COMMON/SETUP2/SUPREZ, BAKLOG
C
C      COMMON/UPDB1/UNITFL(30), ACTYPE(30), ROUTE(30), RECLGC(30),
1  LENGTH(85), NXTARR, RAN1, RAN2, ENTNUM, LSTAPR(14),
2  NXTTYP, NXTIPA, NXTRUT, TYTOGO(6,6,4)
C
C      COMMON/CPS/ORDER(10), FCFSNM(9), COUNT, FRSTNU(30), BSTOFF
1  , MXPERM, TOTLAC, ENTRWF(30), ENTRWS(30), ORDROW(10)
2  , MORE, NXTROW, LNDCLS(30), PERM(9), ASNNUM(30), NOPERM
3  , FSTMOR, AMOUNT(9), SWITCH, BSTSWI, BSTORD(10), TIE, OFFRUT, PRIORT
4  , ASSYGN(30), NOMTYM(30), ASNTYM(30), INFEAS, BSTASN(10)
5  , FRSTPE, SEPMIN(3,3), FINAL, FENTNU(30), LEADTM, MPS, NMTEST
6  , MXPFAC, ENTTYM(30)
C
C      DATA RAN1, RAN2, ENTNUM, CLOCK/4*0/
C
C      TYPE 1009
1009 FORMAT(' SEED = ?')
ACCEPT 1002, SEED
IF (SEED.EQ.0) GOTO 1010
C DISCARD THE FIRST "SEED" RANDOM NUMBERS
DO 1011 I=1, SEED
X=RAM(RAN1, RAN2)
1011 CONTINUE
1010 CONTINUE
TYPE 1000
1000 FORMAT(' HOW MANY SECONDS BETWEEN A/C POSITION')
TYPE 1001
1001 FORMAT(' UPDATES? (MUST BE A MULTIPLE OF FOUR)')

```

```

55 ACCEPT 1002, I
1002 FORMAT(I7)
    IF (MOD(I,4).EQ.0)GOTO 50
    TYPE 1003
1003 FORMAT(' THAT IS NOT A MULTIPLE OF 4, PLEASE TRY AGAIN')
    GO TO 55
50 UPDATE=I/4
    NXTARR=I
    I=0 'UPDATE E&S AS SOON AS POSSIBLE
60 DELTA=I*1000
    TYPE 1013
1013 FORMAT(' TYPE 1 TO OUTPUT FINAL',
1 ' STATISTICS ONLY')
    ACCEPT 1002, SUPREZ
70 TYPE 1014
1014 FORMAT(' HOW MUCH IS THE INITIAL DELAY (IN SECONDS)?')
    ACCEPT 1002, BAKLOG
    IF (BAKLOG GE. 0)GOTO 75
    TYPE 1015
1015 FORMAT(' INVALID ANSWER: CANNOT BE NEGATIVE')
    GOTO 70
75 TYPE 1007
1007 FORMAT(' WHAT IS THE APPROXIMATE ARRIVAL RATE(A/C PER HOUR)?')
    ACCEPT 1002, ARATE
    ARRATE=ARATE*1.25
    TYPE 1012
1012 FORMAT(' ENTER MPS')
    ACCEPT 1002, MPS
    PRINT 1016, SEED, NXTARR, ARATE, MPS
1016 FORMAT(' SEED =', I6, ' UPDATE INTERVAL =', I4,
1 ' ARRIVAL RATE =', I4, ' MPS =', I3)
    RETURN
    END

```

```

C
SUBROUTINE BLDESX
C
C   IMPLICIT INTEGER (A-Z)
C
COMMON/SIGCOM/N1234, I HOUR, MNSEC, NACTV, IQACTV(30),
1 IX(30), IY(30), IALT(30), IHGD(30), IPACTV(30), KODERT(30),
1 N4321, IFLASH(30), ISPD(30), MSG(30), IQACTV(30), NARV,
1 IQARV(10), ITPARV(10), IFFARV(10), ISTA(10), ITARV(10),
1 MSG1, MSG2, IKNT, IZERO, IXB, IYB, IXC, IYC, IFLSH, IDSPBC, IDUM(32)
C
COMMON/DISPLY/ TIME, TABLE1(10,35), TABLE2(20), FEDFIX(6),
1 ACTVT1, TIMETB(8), TAGTBL(8,30), MSGTBL(9,30), LIMSG
C
COMMON/SCOPES/INAS, IFAS, IBUS
C
COMMON/DSPDAT/ACTIVE(30), ALFF(30), ILEAD(2,30), LEADER(2,3)
C
COMMON/SETUP1/UPDATE, DELTA, ARRAT, CLOCK
C
DIMENSION ICRS(8), ICRSF(8), WAYPTA(2,70), WAYPTF(2,25),
1 IRNWYA(4), IRNWYF(4), IWP5(2,5), IRG12(2,8)
C
DIMENSION IACTAC(30), IWP1(2), IWP2(2,4),
1 IWP3(2,4), IWPC(2,4), IRG12A(2,4)
C
DIMENSION C(5)
C
C* BUILD THE MAP AND WAYPOINTS
C
DATA ICRS/-25536,364,-25536,-364,-25900,0,-25171,0/
C
DATA ICRSF/-850,1579,-850,850,-1215,1215,-486,1215/
C
DATA WAYPTA/-19845,-23955,-18118,-22228,-16464,-20428,-14810,
1 -18629,-24003,-18264,-21815,-17218,-19577,-16124,-17437,
1 -15054,-20890,-12524,-19893,-8439,-28770,4961,-26362,5447,
1 -23979,5958,-21571,6444,-10263,8852,-15735,20282,
1 -16756,22471,-17826,24709,-18823,26897,-2140,20550,
1 8414,28892,8536,26484,8706,24052,8852,21596,

```

1 9533,9825,16805,16707,16513,19091,16318,21523,  
 1 16075,23955,18896,18726,20672,20404,20842,20550,  
 1 22593,21936,22909,21352,24538,23420,25244,22204,  
 1 11649,-6347,17072,-10190,5447,-11016,21985,-12597,  
 1 24198,-13667,26362,-14689,28576,-15759,18410,-15443,  
 1 19018,-17826,19601,-20209,20234,-22641,-2432,-29184,  
 1 -29244,-1094,30339,15929,30339,3100,19456,-26752,  
 1 -4572,-21742,-4183,-24125,-3769,-26557,-3404,-28940,  
 1 -6517,-9655,-4450,-6615,-1386,-2091,705,-1629,  
 1 -8828,7831,-5982,5861,5763,6128,6177,3210,  
 1 6663,-389,1167,11357,-10165,-3745,7077,-3283,  
 1 1118,1653,0,0/  
  
 DATA IWP5/1487,143,1057,43,2575,393,3200,537,4128,753/  
  
 DATA IRG12/6694,1844,4019,1227,4075,989,2653,660,2762,  
 1 189,4184,517,4237,279,6913,896/  
  
 DATA WAYP15/7071,-3280,6172,3207,6658,-388,5759,6123,-1385,  
 1 -2089,704,-1628,1798,-1287,1642,179,2308,364,3086,558,  
 2 6609,1385,575,-65,243,4860,1458,4860,972,4860,972,  
 3 5589,2624,1895,3013,1336,3255,656,3329,-72,3280,-729,  
 4 315,-826,145,291,72,777,1117,1652/  
  
 DATA IRNWYA/-1208,-486,340,-121/  
  
 DATA IRNWYF/-72,-218,340,-121/  
  
 DATA IRG12A/18021,4460,4023,1228,4241,280,18240,3512/  
 DATA INAS,IFAS,IBUS,IDSPBC,IFLSH/1,2,3,0,0/  
 DATA NARV,MSG1,MSG2,NACTV/4\*0/  
 DATA LIMSG,ACTVT1/2\*0/  
 DATA ACTIVE/30\*0/  
 DATA ALFF/30\*180/  
 DATA LEADER/3000,4000,5000,928,1238,1548/  
 CALL CUIOR(5)  
 INAS=1  
 IFAS=3  
 IBUS=4

C

C

C

C

C

C

```

C
C* DISPLAY THE TIME
C
      HOURS=CLOCK/3600
      MIN=CLOCK/60-HOURS*60
      SEC=CLOCK-HOURS*3600-MIN*60
      ENCODE(2,102,C(1))HOURS
      ENCODE(2,102,C(3))MIN
      ENCODE(2,102,C(5))SEC
      102 FORMAT(I2)
      C(2)=' '
      C(4)=' '
      DO 900 I=1,2
      CALL SCOPE(IBUS) !TURN ON BACKUP SCOPE
      IF(I.EQ.2)GOTO 901
C    SET UP NORTH SCOPE
      CALL SCOPE(-IFAS) !TURN OFF FINAL SCOPE
      CALL SCOPE(INAS) !TURN ON APPROACH SCOPE
      IF(ISWSET(1).EQ.0)CALL SCOPE(-IBUS) !TURN OFF BACKUPSCOPE
      CALL VWPOR(-2048,2047,-2048,2047,255,255)
      CALL PUSH
      GOTO 902
C    SET UP FINAL SCOPE
      901 CALL SCOPE(-INAS) !TURN OFF APPROACH SCOPE
      CALL SCOPE(IFAS) !TURN ON FINAL SCOPE
      IF(ISWSET(1).NE.0)CALL SCOPE(-IBUS) !TURN OFF BACKUP SCOPE
      CALL VWPOR(-1224,1224,-1366,1366,255,255)
      CALL WINDOW(-1362,7077,-3283,6129)
      CALL PUSH
C    DISPLAY WAYPOINTS AND RUNWAY
      902 CALL POP
      DO ,90 J=1,2
      CALL DRAW2D(WAYPTA,70,4,2,0)
      190 CONTINUE
      IF(I.EQ.2)GOTO 903
      CALL DRAW2D(IRNWAYA,2,2,2,0)
      CALL DRAW2D(ICRS,4,0,2,0)
      IF(ISWSET(3).NE.0)CALL DRAW2D(IPG12A,4,2,2,0)
      CALL CHAR(1,1,0)

```

```

CALL MOVETO(-30000,30000)
CALL TEXT(10,C)
CALL CHAR(0,0,0)
GOTO 904

903 CALL DRAW2D(ICRSF,4,0,2,0)
CALL MOVETO(IRNWYF(1),IRNWYF(2))
CALL LINETO(IRNWYF(3),IRNWYF(4))
DO 200 J=1,2
CALL DRAW2D(WAYPTF,25,4,2,0)
CALL CHAR(0,0,0)
200 CONTINUE

CALL CHAR(1,1,0)
CALL MOVETO(-1300,6100)
CALL TEXT(10,C)
IF(ISWSET(3).EQ.0)GOTO 904
CALL DRAW2D(IRG12,8,2,2,0)
DO 76 J=1,10
CALL DRAW2D(IWP5,5,4,2,0)
76 CONTINUE

904 IF(IDSPBC.EQ.0)GOTO 192
IF(IFLSH.NE.0)CALL BLINK(1)
IWP1(1)=IXB !IXB IN E&S BITS
IWP1(2)=IYB !IYB IN E&S BITS
CALL DRAW2D(IWP1,1,4,2,0)
CALL BLINK(0)
IWP2(1,1)=IXC+486 !IXC IN E&S BITS
IWP2(2,1)=IYC+486 !IYC IN E&S BITS
IWP2(1,2)=IXC-486 !CONVERSION FOR FINAL MIGHT NOT
IWP2(2,2)=IYC-486 !BE 486 BUT K(1) WITH K(1)=486
IWP2(1,3)=IWP2(1,1)
IWP2(2,3)=IWP2(2,2)
IWP2(1,4)=IWP2(1,2)
IWP2(2,4)=IWP2(2,1)
CALL DRAW2D(IWP2,4,0,2,0)
192 CONTINUE

CALL PUSH
DO 905 J=1,50
CALL POP
CALL PUSH

```

```
IF(ACTIVE(J).EQ.0)GOTO 905
906 CALL ACDRAW(I,J)
905 CONTINUE
CALL POP
900 CONTINUE
CALL POP
CALL PUSH
IF(ISWSET(6).EQ.0)GO TO 910
PAUSE 'TURN OFF SWITCH 6 AND HIT THE RETURN TO CONTINUE'
910 CONTINUE
RETURN
END
```



```

C      SUBROUTINE ACDRAW(I1,J1)
C
C      IMPLICIT INTEGER (A-Z)
C
COMMON/SIGCOM/N1234, I HOUR, MNSEC, NACTV, IGACTV(30),
1 IX(30), IY(30), IALT(30), IHGD(30), IPACTV(30), KODERT(30),
1 N4321, IFLASH(30), ISPD(30), MSG(30), IGACTV(30), NARV,
1 IQARV(10), ITPARV(10), IFFARV(10), ISTA(10), ITARV(10),
1 MSG1, MSG2, IKNT, IZERO, IXB, IYB, IXC, IYC, IFLSH, IDSPBC, IDUM(32)
C
COMMON/DSPDAT/ACTIVE(30), ALFF(30), ILEAD(2,30), LEADER(2,3)
C
COMMON/INFO/ ACID(50), ALINE(5), SIZE(3)
C
COMMON/HOLD1/NXTFNL, MINTRP, HOLD(30), NXSTAR(30), FINASN(30)
1 , LSTREC(14), STOPAC(30), NEWOUT
C
COMMON/CPS/ORDER(10), FCFSNM(9), COUNT, FRSTNU(30), BSTOFF
1 , MXPERM, TOTLAC, ENTRWF(30), ENTRWS(30), ORDRDU(10)
2 , MORE, NXTROW, LNDCLS(30), PERM(9), ASNNUM(30), NOPERM
3 , FSTMOR, AMOUNT(9), SWITCH, BSTSWI, BSTORD(10), TIE, OFFRUT, PRIORT
4 , ASSYGN(30), NDMTYM(30), SNTYM(30), INFEAS, BSTASN(10)
5 , FRSTPE, SEPMIN(3,3), FINAL, FENTNU(30), LEADTM, MPS, NMTEST
6 , MXPFAC, ENTTYM(30)
C
DIMENSION ACRFT1(10), ACRFT2(10), ITAG(4), LINE(2)
C
DATA ALINE, SIZE/'CG', 'UA', 'FL', 'TW', 'WA', 'L', ' ', 'H'/
C
REAL D2R, XALF
C
DATA ACRFT1/500, 0, -1000, 500, 0, -1000, 1000, 500, -1000, 0/
DATA ACRFT2/144, 0, -286, 139, 0, -278, 288, 139, -288, 0/
DATA LINE/480, 120/
DATA ITAG/4*0/
DATA D2R/.01745/
C
C*  DRAW THE AIRCRAFT ON THE DISPLAY
C

```

```

XALF=ALFF(J1)*D2R
LDR=ILEAD(I1,J1)
ITAG(3)=LDR*SIN(XALF)
ITAG(4)=LDR*COS(XALF)
IX1=ITAG(3)+IX(J1)+LINE(I1)
IY1=ITAG(4)+IY(J1)-LINE(I1)
CALL MOVETO(IX1,IY1)
IF(I1.EG.1)GOTO 20
IF(IX1.LT.-1362.OR.IX1.GT.7077.OR.
1 IY1.LT.-3283.OR.IY1.GT.6129)GOTO 10
20 CONTINUE
CALL CHAR(0,0,0)
CALL TEXT(2,ACID(J1))
IT=IPACTV(J1)
ENCODE(2,103,ARRNUM)FENTNU(J1)
CALL TEXT(2,ARRNUM)
CALL TEXT(1,SIZE(IT))
103 FORMAT(I2)
IY2=IY1-LINE(I1)*2
ENCODE(3,102,ALTAG)IALT(J1)
102 FORMAT(I3)
CALL MOVETO(IX1,IY2)
CALL TEXT(3,ALTAG)
IX2=IX1+5*LINE(I1)
ENCODE(3,102,SPDTAG)ISPD(J1)
CALL MOVETO(IX2,IY2)
CALL TEXT(3,SPDTAG)
10 CONTINUE
CALL TRAN(IX(J1),IY(J1),0)
CALL DRAW2D(ITAG,2,2,2,0)
IT=IHGD(J1)/182
IF(IT.GE.-90)A=IT+90
IF(IT.LT.-90)A=IT+450
IF(A.LE.180)ITT=182*A
IF(A.GT.180)ITT=182*(A-360)
CALL ROT(-ITT,3)
CALL ROT(16384,3)
IF(IFLASH(J1).NE.0)CALL BLINK(1)
IF(HOLD(J1).NE.0)CALL BLINK(1)

```

```
IF(STOPAC(J1).NE.0)CALL BLINK(1)
IF(I1.EQ.1)CALL DRAW2D(ACRFT1,5,2,0,0)
IF(I1.EQ.2)CALL DRAW2D(ACRFT2,5,2,0,0)
CALL BLINK(0)
RETURN
END
```

```

SUBROUTINE FRMSGX
C
C   IMPLICIT INTEGER(A-Z)
C
COMMON/SIGCOM/N1234, I HOUR, MNSEC, NACTV, I GACTV(30),
1 IX(30), IY(30), IALT(30), IMGD(30), IPACTV(30), KODERT(30),
1 N4321, IFLASH(30), ISPD(30), MSG(30), I GACTV(30), NARV,
1 I G ARV(10), ITPARV(10), IFFARV(10), ISTA(10), I TARV(10),
1 MSG1, MSG2, IKNT, IZERO, IXB, IYB, IXC, IYC, IFLSH, IDSPBC, IDUM(32)
C
COMMON/DISPLY/ TIME, TABLE1(10,35), TABLE2(30), FEDFIX(6),
1 ACTVT1, TIMETB(8), TAGTBL(8,30), MSGTBL(9,30), LIMSG
C
DIMENSION RUTEID(2,11)
C
DATA BLANK2/' '//
C
C* GET THE UPDATED INFORMATION
C
CALL SIGIOX
C
C* BUILD TAG TABLE
C
CALL FILL(240,BLANK2,TAGTBL(1,1))
C
C* GET TIME
C
ENCODE(2,1002,TIMETB(1)) I HOUR
TIMETB(2)=', '
ENCODE(2,1002,TIMETB(3)) MNSEC/60
TIMETB(4)=', '
ENCODE(2,1002,TIMETB(5)) MOD(MNSEC,60)
MSGLIN=0
LIMSG=0
C
C* A/C DATA
C
IF(NACTV .EQ. 0) GO TO 25
DO 18 IAC=1,NACTV

```

```
18      TAGTBL(1,IAC)=IQACTV(IAC)
25      ENCODE(2,1002,TAGTBL(4,IAC))IPACTV(IAC)
      ENCODE(3,1003,TAGTBL(5,IAC))IALT(IAC)
      ENCODE(3,1003,TAGTBL(7,IAC))ISPD(IAC)
      CONTINUE
      CONTINUE
      RETURN
1002     FORMAT(12)
1003     FORMAT(13)
1005     FORMAT(15)
      END
```

```

C      SUBROUTINE SIGIOX
C
C      IMPLICIT INTEGER(A-Z)
C
C      COMMON/SIGCOM/N1234, I HOUR, MNSEC, NACTV, IGACTV(30),
1 IX(30), IY(30), IALT(30), IHGD(30), IPACTV(30), KODERT(30),
1 N4321, IFLASH(30), ISPD(30), MSG(30), IGACTV(30), NARV,
1 IGARV(10), ITPARV(10), IFFARV(10), ISTA(10), ITARV(10),
1 MSG1, MSG2, IKNT, IZERO, IXB, IYB, IXC, IYC, IFLSH, IDSPBC, IDUM(32)
C
C      COMMON/SETUP1/UPDATE, DELTA, ARRATE, CLOCK
C
C      COMMON/DSPDAT/ACTIVE(30), ALFF(30), ILEAD(2,30), LEADER(2,3)
C
C*    DELTA=0, SO UPDATE AS FAST AS POSSIBLE
C
700   CALL READC(NUM)
      IF(NUM.LT.DELTA)GOTO 700
C
C*    CHECK FOR ANY FINAL ASSIGNMENTS
C
      CALL MKEFNL
C
C*    GET NEW POSITION DATA: REVISE TENTATIVE SCHEDULE IF REQUIRED
C
      CALL UPDB
C
      RETURN
C
      END

```

```

C
SUBROUTINE UPD8
C
C      IMPLICIT INTEGER(A-Z)
C
COMMON/SIGCOM/N1234, IHOUR, MNSEC, NACTV, IGACTV(30),
1 IX(30), IY(30), IALT(30), IHGD(30), IPACTV(30), KODERT(30),
1 N4321, IFLASH(30), ISPD(30), MSG(30), IGACTV(30), NARV,
1 IGARV(10), ITPARV(10), IFFARV(10), ISTA(10), ITARV(10),
1 ISG1, ISG2, IKNT, IZERO, IXB, IYB, IXC, IYC, IFLSH, IDSPBC, IDUM(32)
C
COMMON/SETUP1/UPDATE, DELTA, ARRATE, CLOCK
C
COMMON/DSPDAT/ ACTIVE(30), ALFF(30), ILEAD(2,30), LEADER(2,3)
C
COMMON/UPD81/UNITFL(30), ACTYPE(30), ROUTE(30), RECLOC(30),
1 LENGTH(85), NXTARR, RAN1, RAN2, ENTNUM, LSTARR(14),
2 NXTTYP, NXTIPA, NXTRUT, TYTCGO(6,6,4)
C
COMMON/HOLD1/NXTFNL, MINTRP, HOLD(30), NXSTAR(30), FINASN(30)
1 , LSTREC(14), STOPAC(30), NEWOUT
C
COMMON/CPS/ORDER(10), FCFSNM(9), COUNT, FRSTNU(30), BSTOFF
1 , MXPERM, TOTLAC, ENTRWF(30), ENTRWS(30), ORDROW(10)
2 , MORE, NXTROW, LNDCLS(30), PERM(9), ASNNUM(30), NOPERM
3 , FSTMR, AMOUNT(9), SWITCH, BSTSWI, BSTORD(10), TIE, OFFRUT, PRIORT
4 , ASSYGN(30), NONTYM(30), ASNTYM(30), INFEAS, BSTASN(10)
5 , FRSTPE, SEPMIN(3,3), FINAL, FENTNU(30), LEADTH, MPS, NMTEST
6 , MXPFAC, ENTTYM(30)
C
DATA IGACTV, IFLASH, IGACTV, IPACTV, KODERT/60*0, 30*1, 60*2/
DATA LENGTH/0, 405, 19*0, 356, 11*0, 408, 24*0, 613, 12*0,
1 524, 12*0, 374/
CLOCK=CLOCK+UPDATE*4
C
C* CHECK FOR A NEW ARRIVAL
C
IF(CLOCK GE NXTARR)CALL GENER8
DO 14 I=1, 14
LSTREC(I)=700

```

```

14 CONTINUE
C
C* DETERMINE THE AIRCRAFT POSITION ON THE DISPLAY
C
DO 915 M=1,ENTNUM
  IT=M
  K1=ROW(IT)
  K=ENTRWS(K1)
  STOPAC(K)=0
  IF(ACTIVE(K).EQ.0)GOTO 915
  RUT=ROUTE(K)
  TY=ATYPE(K)
  ENHLD=0
  IF(FINASN(K).EQ.0)GOTO 10
  IF(HOLD(K).EQ.0)GOTO 10
  IF(CLOCK.GT.NXSTAR(K))ENDHLD=1
  IF(ENDHLD.NE.0)HOLD(K)=0
  LSTREC(RUT)=RECLOC(K)-UPDATE
  IF(HOLD(K).NE.0)GOTO 915
10 CONTINUE
  U=UNITFL(K)
  R=RECLOC(K)
  IF(ENDHLD.EQ.0)GOTO 12
  T1=(LENGTH(U)-R+1)*4
  T3=ASNTYM(K)-CLOCK-T1
  T4=T3/4
  T=MOD(T4,UPDATE)
  R=R-T
  LSTREC(RUT)=699
12 CONTINUE
  SEP=2
  IF(IPACTV(K).EQ.1)SEP=4
  IF(IPACTV(K).EQ.3)SEP=3
  T2=TY*GO(TY,1,SEP)
  L1=LS(REC(RUT))
  IF(R.GT.L1-T2)STOPAC(K)=1
  IF(R.GT.L1-T2)R=L1-T2
  IT=RECLOC(K)
  LSTREC(RUT)=R

```



```

C
C* CHECK FOR AN AIRCRAFT LANDING
C
      IF(R.GT.LENGTH(U))GOTO 916
      IF(R.LT.1)R=1
      READ(U/R)IX(K),IY(K),IALT(K),ISPD(K),IHGD(K)
      RECLOC(K)=R+UPDATE
      GOTO 915
916 ACTIVE(K)=0 !REMOVE AIRCRAFT
      NACTV=NACTV-1
915 CONTINUE
      RETURN
      END

```

```

SUBROUTINE GENERB
  IMPLICIT INTEGER(A-Z)

  COMMON/SIGCOM/N1234, I HOUR, MNSEC, NACTV, IQACTV(30),
  1 IX(30), IY(30), IALT(30), IHGD(30), IPACTV(30), KODERT(30),
  1 N4321, IFLASH(30), ISPD(30), MSG(30), IQACTV(30), NARV,
  1 IQARV(10), ITPARV(10), IFFARV(10), ISTA(10), ITARV(10),
  1 MSG1, MSG2, IKNT, IZERO, IXB, IYB, IXC, IYC, IFLSH, IDSPBC, IDUM(32)

  COMMON/SETUP1/UPDATE, DELTA, ARRATE, CLOCK

  COMMON/DSPDAT/ACTIVE(30), ALFF(30), ILEAD(2,30), LEADER(2,3)

  COMMON/UPDB1/UNITFL(30), ACTYPE(30), ROUTE(30), RECLOC(30),
  1 LENGTH(85), NXTARR, RAN1, RAN2, ENTNUM, LSTARR(14),
  2 NXTTYP, NXTIPA, NXTRUT, TYTOGD(6,6,4)

  COMMON/CPS/ORDER(10), FCFSNM(9), COUNT, FRSTNU(30), BSTOFF
  1 , MXPERM, TOTLAC, ENTRWF(30), ENTRWS(30), ORDRW(10)
  2 , MORE, NXTROW, LNDCLS(30), PERM(9), ASNNUM(30), NOPERM
  3 , FSTMR, AMOUNT(9), SWITCH, BSTSWI, BSTORD(10), TIE, OFFRUT, PRIOR
  4 , ASSYGN(30), NOMTYM(30), ASNTYM(30), INFEAS, BSTASN(10)
  5 , FRSTPE, SEPMIN(3,3), FINAL, FENTNU(30), LEADTM, MPS, NMTEST
  6 , MXPFAC, ENTTYM(30)

  COMMON/HOLD1/NXTFNL, MINTRP, HOLD(30), NXSTAR(30), FINASN(30)
  1 , LSTREC(14), STOPAC(30), NEWOUT

  COMMON/INFO/ACID(50), ALINE(5), SIZE(3)

  DATA LSTARR, NXTTYP, NXTIPA, NXTRUT/14*-92,2,2,7/

  DATA MPS/0/

  DIMENSION RUTES(6), TYPES(6)

  REAL CUMPRB(6)

```

DATA CUMPRB/. 25, . 45, . 65, . 75, . 85, 1. 0/  
 DATA RUTES, TYPES/2, 4, 7, 14, 12, 10, 3, 2, 2, 1, 2, 2/

REAL X, RAN, ALOG, ENTINT

IF(ENTNUM.EQ.30)RETURN  
 IF(ENTNUM.EQ.0)GO TO 150

155 CONTINUE  
 NEWOUT=1

SEP=2

IF(NXTIPA.EQ.1)SEP=4  
 IF(NXTIPA.EQ.3)SEP=3  
 ENTNUM=ENTNUM+1

J=ROW(ENTNUM)

FINAL=J

REWIND 7

ENTRWF(J)=J

FRSTNU(J)=ENTNUM

FENTNU(J)=ENTNUM

ACTYPE(J)=NXTTYP

IPACTV(J)=NXTIPA

ROUTE(J)=NXTROUTE

C\* SELECT AN AIRLINE TAG

150 X=RAN(RAN1,RAN2)

IT=10\*X

ITT=MOD(IT,5)+1

ACID(J)=ALINE(ITT)

X=RAN(RAN1,RAN2)

C\* SELECT AN AIRCRAFT TYPE (LIGHT, CONVENTIONAL OR HEAVY)

DO 50 I=1,6

IF(X.LT.CUMPRB(I))GO TO 100

50 CONTINUE

100 NXTTYP=I

IF(I.EQ.2)NXTTYP=3

6-2

```

IF(1.EQ.3)NXTTYP=2
NXTIPA=TYPES(I)
NXTRUT=RUTES(I)
IF(ENTNUM.EQ.0) GO TO 155
RJ=ROUTE(J)
JT=LASTARR(RJ)
LSTARR(RJ)=NXTARR
UNITFL(J)=(ATYPE(J)-1)*15 + RJ
RECLOC(J)=(CLOCK-NXTARR)/4+1
U=UNITFL(J)
ENTTYM(J)=NXTARR
NOMTYM(J)=LENGTH(U)*4+NXTARR
NACTV=NACTV+1
ACTIVE(J)=1
ILEAD(1,J)=LEADER(1,2)
ILEAD(2,J)=LEADER(2,2)
X=РАН(RAN1,RAN2)

```

```

C
C* DETERMINE THE INTERARRIVAL TIME
C

```

```

ENTINT=-3600.*ALOG(X)/ARRATE+2
IF(ENTINT.GT.180)ENTINT=180
ENTCNT=ENTINT/4
IF(ENTCNT.EQ.0)ENTCNT=1
NXTARR=CLOCK+ENTCNT*4
IT=LASTARR(NXTRUT)+92
IF(NXTARR-IT.LT.0)NXTARR=IT

```

```

C
C* START THE CPS ALGORITHM
C

```

```

CALL SORT
360 CALL GETSET
B4=0
DO 350 K1=1,MXPFA
CALL GETPRN
IF(B4.EQ.1)GOTO 500

```

```

C
C* DETERMINE THE INITIAL DELAY
C

```

```
700 CALL INIDL
    B4=1
500 CONTINUE
    CALL FEZTST
    IF (INFEAS.NE. 0)GOTO 350
    CALL SKEDUL
    CALL COMPAR
350 CONTINUE
    CALL STORE
    IF (MORE.NE. 0)GOTO 360
    RETURN
    END
```

```

C      SUBROUTINE INITDL
C
C      IMPLICIT INTEGER(A-Z)
C
C      COMMON/SIGCOM/N1234, I HOUR, MNSEC, NACTV, IGACTV(30),
1 IX(30), IY(30), IALT(30), IHGD(30), IPACTV(30), KODERT(30),
1 N4321, IFLASH(30), ISPD(30), MSG(30), IGACTV(30), NARV,
1 IQARV(10), ITPARV(10), IFFARV(10), ISTA(10), ITARV(10),
1 MSG1, MSG2, IKNT, IZERO, IXB, IYB, IXC, IYC, IFLSH, IDSPBC, IDUM(32)
C
C      COMMON/UPDB1/UNITFL(30), ACTYPE(30), ROUTE(30), RECLOC(30),
1 LENGTH(85), NXTARR, RANI, RAN2, ENTNUM, LSTARR(14),
2 NXTTYP, NXTIPA, NXTRUT, TYTOGO(6,6,4)
C
C      COMMON/CPS/ORDER(10), FCFSNM(9), COUNT, FRSTNU(30), BSTOFF
1 , MXPERM, TOTLAC, ENTRWF(30), ENTRWS(30), ORDROW(10)
2 , MORE, NXTROW, LNDCLS(30), PERM(9), ASNNUM(30), NQPERM
3 , FSTMOR, AMOUNT(9), SWITCH, BSTSWI, BSTORD(10), TIE, OFFRUT, PRIORT
4 , ASSYGN(30), NDMTYM(30), ASNTYM(30), INFEAS, BSTASN(10)
5 , FRSTPE, SEPMIN(3,3), FINAL, FENTNU(30), LEADTM, MPS, NMTEST
6 , MXPFAC, ENTTYM(30)
C      COMMON/INTDL1/MERGE(14,14), INITDL(30), INTASN(30)
C
C      COMMON/SETUP1/UPDATE, DELTA, ARRATE, CLOCK
C
C      COMMON/SETUP2/SUPREZ, BAKLOG
C
C      COMMON/INFO/A:ID(50), ALINE(5), SIZE(3)
C
C      DIMENSION B4(10)
C
C*      DETERMINE IF AN INITIAL DELAY IS INEVITABLE
C
C      S=0
      INITIAL=ORDROW(10)
      IF(MXPERM.GE.0)GOTO 10
      INITDL(FINAL)=BAKLOG
      GOTO 310
10 IF(MXPERM.EQ.0)GOTO 200

```

```

I3=ROUTE(FINAL)
K3=ATYPE(FINAL)
DO 100 I=1,MXPERM
J=ORDROW(I)
I4=ROUTE(J)
K=ATYPE(J)
IF(I4.NE.I3)GOTO 100
IF(K.NE.K3)GOTO 100
S=S+1
E4(S)=J
100 CONTINUE
200 B4(S+1)=FINAL
INTASN(INITIAL)=ASNTYM(INITIAL)
MMT=S+1
DO 12 JJ=1,MMT
IF(JJ.EQ.1)J1=INITIAL
IF(JJ.NE.1)J1=J2
IF(JJ.EQ.MMT)J2=FINAL
IF(JJ.NE.MMT)J2=B4(MMT-JJ)
I1=ROUTE(J1)
I2=ROUTE(J2)
;I1=ATYPE(J1)
K2=ATYPE(J2)
SEP=2
IF(IPACTV(J1).EQ.1)SEP=4
IF(IPACTV(J1).EQ.3)SEP=3
M2=NOTYM(J2)
M3=INTASN(J1)+TYTOGO(K2,1,SEP)*4
M1=MAXO(M2,M3)
IF(I1.EQ.I2)GOTO 20
IT=MERGE(I1,I2)
T1=TYTOGO(K1,IT,1)*4
T2=TYTOGO(K2,IT,1)*4
IF(T2.GE.T1)GOTO 15
20 INTASN(J2)=M1
GOTO 12
15 T3=TYTOGO(K2,IT,SEP)*4
U2=UNITFL(J2)
M2=LENGTH(U2)*4-T2

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```

M4=ENTTYM(J2)+M2
M5=INTASN(J1)-T1
M6=M5+T3-T2
M7=MAXO(M4,M6)
  INTASN(J2)=MAXO(M1,M7+T2)
12 CONTINUE
  INITDL(FINAL)=INTASN(FINAL)-NCITYM(FINAL)
310 CONTINUE
  RETURN
  END
```



```

SUBROUTINE SORT
C
  IMPLICIT INTEGER(A-Z)
C
  COMMON/CPS/ORDER(10),FCFSNM(9),COUNT,FRSTNU(30),BSTOFF
1  ,MXPERM,TOTLAC,ENTRWF(30),ENTRWS(30),ORDROW(10)
2  ,MORE,NXTROW,LNDCLS(30),PERM(9),ASNNUM(30),NOPERM
3  ,FSTMOR,AMOUNT(9),SWITCH,BSTSWI,BSTORD(10),TIE,OFFRUT,PRIORIT
4  ,ASSYGN(30),NOMTYM(30),ASNTYM(30),INFEAS,BSTASN(10)
5  ,FRSTPE,SEPMIN(3,3),FINAL,FENTNU(30),LEADTM,MPS,NMTEST
6  ,MXPFAC,ENTTYM(30)
C
  COMMON/UPDB1/UNITFL(30),ACTYPE(30),ROUTE(30),RECLOC(30),
1  LENGTH(85),NXTARR,RAN1,RAN2,ENTNUM,LSTARR(100),
2  NXTTYP,NXTIPA,NXTRUT, TYTOGO(6,6,4)
C
  FSTMOR=0
  MORE=0
  J=FINAL
  DO 91 N=1,ENTNUM
    IF(ENTNUM-N.EQ.0)RETURN
    KK=ENTNUM-N
    K=ENTRWF(KK)
    IF(NOMTYM(J).GE.NOMTYM(K))RETURN
    FSTMOR=i
    MORE=1
    NXTROW=K
    FRSTNU(J)=FRSTNU(J)-1
    FRSTNU(K)=FRSTNU(K)+1
    JJ=ROW(FRSTNU(J))
    ENTRWF(JJ)=J
    KK=ROW(FRSTNU(K))
    ENTRWF(KK)=K
91  CONTINUE
    END

```

```

SUBROUTINE GETSET
C
  IMPLICIT INTEGER(A-Z)
C
  COMMON/CPS/ORDER(16),FCFSNM(9),COUNT,FRSTNU(30),BSTOFF
  1 ,MXPERM,TOTLAC,ENTRWF(30),ENTRWS(30),ORDROW(10)
  2 ,MORE,NXTROW,LNDCLS(30),PERM(9),ASNNUM(30),NOPERM
  3 ,FSTMOR,AMOUNT(9),SWITCH,BSTSWI,BSTORD(10),TIE,OFFRUT,PRIORT
  4 ,ASSYGN(30),NOMTYM(30),ASNTYM(30),INFEAS,BSTASN(10)
  5 ,FRSTPE,SEPMIN(3,3),FINAL,FENTNU(30),LEADTM,MPS,NMTEST
  6 ,MXPFAC,ENTTYM(30)
C
  COMMON/UPDB1/UNITFL(30),ACTYPE(30),ROUTE(30),RECLDC(30),
  1 LENGTH(85),NXTARR,RAN1,RAN2,ENTNUM,LSTARR(14),
  2 NXTTYP,NXTIPA,NXTRUT,TYTOGO(6,6,4)
C
  NMTEST=0
  IF(FSTMOR.EQ.0)GOTO 431
  FSTMOR=0
  GOTO 421
431 IF(MORE.EQ.0)GOTO 421
  FINAL=NXTROW
  IF(FRSTNU(NXTROW).EQ.ENTNUM)MORE=0
  IF(MORE.EQ.1)NXTROW=ENTRWF(FRSTNU(FINAL)+1)
421 LAST=FRSTNU(FINAL)
  MXPERM=MINO(MPS+1,LAST-2)
  MXPFAC=1
  IF(MXPERM.LE.0)GOTO 320
  DO 340 K1=1,MXPERM
    MXPFAC=K1*MXPFC
  340 CONTINUE
  320 FRSTPE=1
  NOPERM=0
  K=MAXO(LAST-MPS-2,1)
  M=ROW(K)
  IF(LAST.EQ.1)ENTRWS(1)=FINAL
  INITIAL=ENTRWS(M)
  ORDROW(10)=INITIAL
  ORDER(10)=FRSTNU(INITIAL)

```

```

      IF (MXPERM. GE. 0) GOTO 101
      NOPERM=1
      RETURN
101  ORDROW (MXPERM+1)=FINAL
      ORDER (MXPERM+1)=LAST
      IF (MXPERM. GT. 0) GOTO 10
      NOPERM=1
      RETURN
10  MM=0
      DO 71 JJ=1, 100
      IT=ROW(LAST-JJ)
      IF (ASINUM(ENTRWF(IT)). LE. K) GOTO 71
      MM=MM+1
      AMOUNT(MM)=1
      PERM(MM)=MM
      FCFSNM(MM)=FRSTNU(ENTRWF(IT))
      IF (MM. EQ. MXPERM) GOTO 441
      71 CONTINUE
441  RETURN
      END

```

```

C      SUBROUTINE GETPRM
C
C      IMPLICIT INTEGER(A-Z)
C
COMMON/CPS/ORDER(10),FCFSNM(9),COUNT,FRSTNU(30),BSTOFF
1 ,MXPERM,TOTLAC,ENTRWF(30),ENTRWS(30),ORDROW(10)
2 ,MORE,NXTROW,LNDCLS(30),PERM(9),ASNNUM(30),NOPERM
3 ,FSTMOR,AMOUNT(9),SWITCH,BSTSWI,BSTORD(10),TIE,OFFRUT,PRIORT
4 ,ASSYGN(30),NOMTYM(30),ASNTYM(30),INFEAS,BSTASN(10)
5 ,FRSTPE,SEPMIN(3,3),FINAL,FENTNU(30),LEADTM,MPS,NMTEST
6 ,MXPFAC,ENTTYM(30)
C
COMMON/UPDB1/UNITFL(30),ACTYPE(30),ROUTE(30),RECLOC(30),
1 LENGTH(85),NXTARR,RAN1,RAN2,ENTNUM,LSTARR(14),
2 NXTTYP,NXTIPA,NXTRUT,TYTOGO(6,6,4)
C
COMMON/SETUP2/SUPREZ,BAKLOG
C
IF(MXPERM.NE.-1)GOTO 310
C
C*  A DELAY IS INTRODUCED FOR THE FIRST ARRIVAL
C
ASNTYM(FINAL)=NOMTYM(FINAL)+BAKLOG
ENTRWS(FINAL)=FRSTNU(FINAL)
ASNNUM(FINAL)=FRSTNU(FINAL)
RETURN
310 IF(MXPERM.EQ.0)RETURN
IF(FRSTPE.EQ.0)GOTO 300
FRSTPE=0
GOTO 20
300 IF(MXPERM.EQ.1)GOTO 60
IF(MXPERM.GT.2)GOTO 50
IF(NUM.EQ.2)GOTO 60
50 KT=0
IF(MOD(NUM,2).EQ.0)KT=1
IT=PERM(1+KT)
PERM(1+KT)=PERM(2+KT)
PERM(2+KT)=IT
IF(NUM.NE.6)GOTO 30

```

```

IF(MXPERM.EQ.3)GOTO 60
AMOUNT(4)=AMOUNT(4)+1
IF(AMOUNT(4).LE.4)GOTO 70
80 COUNT=COUNT+1
IF(COUNT.GT.MXPERM)GOTO 60
AMOUNT(COUNT)=AMOUNT(COUNT)+1
IF(AMOUNT(COUNT).GT.COUNT)GOTO 80
IT=COUNT-1
DO 90 I=4,IT
AMOUNT(I)=1
90 CONTINUE
70 KT=COUNT-1
IF(MOD(COUNT,2).EQ.0)KT=COUNT+1-AMOUNT(COUNT)
IT=PERM(COUNT)
PERM(COUNT)=PERM(KT)
PERM(KT)=IT
20 COUNT=4
NUM=0
30 NUM=NUM+1
DO 2 J=1,MXPERM
IT=FCFSNM(PERM(J))
JT=ROW(IT)
ORDROW(J)=ENTRWF(JT)
ORDER(J)=IT
2 CONTINUE
RETURN
60 TYPE 44
44 FORMAT(' TOO MANY PERMUTATIONS')
RETURN
END

```

```

SUBROUTINE FEZTSF
C
C      IMPLICIT INTEGER(A-Z)
C
COMMON/SIGCOM/N1234, IHOUR, MNSEC, NACTV, IGACTION(30),
1 IX(30), IY(30), IALT(30), IHGD(30), IPACTV(30), KODERT(30),
1 N4321, IFLASH(30), ISPD(30), MSG(30), IGACTION(30), NARV,
1 IGARV(10), ITPARV(10), IFFARV(10), ISTA(10), ITARV(10),
1 MSG1, MSG2, IKNT, IZERO, IXB, IYB, IXC, IYC, IFLSH, IDSPBC, IDUM(32)
C
COMMON/SETUP1/UPDATE, DELTA, ARRATE, CLOCK
C
COMMON/DSPDAT/ACTIVE(30), ALFF(30), ILEAD(2,30), LEADER(2,3)
C
COMMON/UPDB1/UNITFL(30), ACTYPE(30), ROUTE(30), RECLOC(30),
1 LENGTH(85), NXTARR, RAN1, RAN2, ENTNUM, LSTARR(14),
2 NXTTYP, NXTIPA, NXTRUT, TYTOGO(6,6,4)
C
COMMON/CPS/ORDER(10), FCFSNM(9), COUNT, FRSTNU(30), BSTOFF
1 , MXPERM, TOTLAC, ENTRWF(30), ENTRWS(30), ORDROW(10)
2 , MORE, NXTROW, LNDCLS(30), PERM(9), ASNNUM(30), NOPERM
3 , FSTMOR, AMOUNT(9), SWITCH, BSTSWI, BSTURD(10), TIE, OFFRUT, PRIORT
4 , ASSYGN(30), NDMTYM(30), SNTYM(30), INFEAS, BSTASN(10)
5 , FRSTPE, SEPMIN(3,3), FINAL, FENTNU(30), LEADTM, MPS, NMTEST
6 , MXPFC, ENTTYM(30)
C
COMMON/HOLD1/NXTFNL, MINTRP, HOLD(30), NXSTAR(30), FINASN(30)
1 , LSTREC(14), STOPAC(30), NEWOUT
C
COMMON/INFO/ACID(50), ALINE(5), SIZE(3)
C
INFEAS=0
IF(MXPERM.LE.0)RETURN
DO 14 I=1,MXPERM
J1=ORDROW(I)
IF(FINASN(J1).EQ.0)GOTO 15
IF(ORDER(I).NE.FRSTNU(J1))GOTO 231
15 CONTINUE
IF(ORDER(I).GT.FRSTNU(FINAL)-MXPERM-1+I+MPS)GOTO 231

```

```

      IF (ORDER(I).LT.FFSTNU(FINAL))-MXPERM-1+I-MPS)GOTO 231
14  CONTINUE
      IF (MXPERM.EQ.1)RETURN
      IT=MXPERM-1
      DO 24 I=1,IT
      JT=I+1
      DO 24 J=JT,MXPERM
      IF (ORDER(I).LT.ORDER(J))GOTO 24
      IF (ATYPE(ORDROW(I)).EQ.ATYPE(ORDROW(J)))GOTO 231
24  CONTINUE
      RETURN
231 INFEAS=1
      RETURN
      END

```

## SUBROUTINE SKEDUL

```

C
C      IMPLICIT INTEGER(A-Z)

COMMON/SIGCOM/N1234, I HOUR, MNSEC, NACTV, IGACTV(30),
1 IX(30), IY(30), IALT(30), IHED(30), IPACTV(30), KODERT(30),
1 N4321, IFLASH(30), ISPD(30), MSG(30), IGACTV(30), NARV,
1 IGARV(10), ITPARV(10), IFFARV(10), ISTA(10), IARV(10),
1 MSG1, MSG2, IKNT, IZERO, IXB, IYB, IXC, IYC, IFLSH, IDSPBC, IDUM(32)

C
COMMON/UPD81/UNITFL(30), ACTYPE(30), ROUTE(30), RECLOC(30),
1 LENGTH(85), NXTARR, RAN1, RAN2, ENTNUM, LSTARR(14),
2 NXTTYP, NXTIPA, NXTRUT, TYTOGO(6, 6, 4)

C
COMMON/CPS/ORDER(10), FCFSNM(9), COUNT, FRSTNU(30) BSTOFF
1 , MXPERM, TOTLAC, ENTRWF(30), ENTRWS(30), ORDROW(10),
2 , MORE, NXTROW, LNDCLS(30), PERM(9), ASNNUM(30), NOPERM
3 , FSTMR, AMOUNT(9), SWITCH, BSTSWI, BSTORD(10), TIE, OFFRUT, PRIORT
4 , ASSYGN(30), NOMTYM(JO), ASNTYM(30), INFEAS, BSTASN(10)
5 , FRSTPE, SEPMIN(3, 3), FINAL, FENTNU(30), LEADTM, MPS, NMTEST
6 , MXPFAC, ENTTYM(30)
COMMON/INTDL1/MERGE(14, 14), INITDL(30), INTASN(30)

C
DATA TYTOGO/6*0, 59, 60, 60, 70, 55, 59, 0, 75, 74, 111
6 , 0, 0, 72, 0, 0, 71, 74, 161, 3*0, 178, 0, 46, 47, 47, 55, 43, 45,
1 17, 18, 18, 24, 17, 17, 72, 73, 72, 93, 68, 73, 0, 86, 85, 135, 0, 0
2 , 83, 3*0, 84, 88, 169, 3*0, 188, 5*0, 76, 0, 23, 29, 29, 36, 22, 28, 76,
3 81, 80, 106, 76, 83, 0, 93, 92, 147, 0, 0, 86, 3*0, 92, 98, 172, 3*0,
4 194, 4*0, 88, 0, 0, 17, 18, 18, 18, 17, 17, 72, 73, 72, 88, 68, 73, 0, 86, 74,
5 129, 0, 0, 83, 3*0, 84, 88, 147, 3*0, 188, 0, 59, 60, 59, 70, 56, 59/

C
DATA MERGE/17*0, 2, 0, 0, 2, 0, 0, 4, 0, 5, 0, 6, 15*0, 2, 4*0
1 , 3, 0, 0, 2, 0, 6, 29*0, 2, 0, 3, 5*0, 2, 0, 2, 0, 6, 29*0, 4, 0, 2
2 , 0, 0, 2, 4*0, 4, 0, 6, 15*0, 5, 0, 2, 0, 0, 2, 0, 0, 4, 0, 0, 6, 15*0, 6, 0
3 , 6, 0, 0, 6, 0, 6, 0, 6, 0, 0/

C
C* SCHEDULE THE AIRCRAFT, TAKING INTO ACCOUNT THE SEPARATION
C* MINIMA AND ROUTE MERGER POINTS
C

```



```

IF(MXPERM.LT.O)RETURN
I3=ORDROW(10)
ASSYGN(I3)=ASNTYM(I3)
IF(ORDER(10).EQ.1)GOTO 16
I=ORDER(10)-1
IT=ROW(I)
J=ENTRWS(IT)
16 *MT=MXPERM+1
DO 12 JJ=1,MMT
IF(JJ.EQ.1)I=10
IF(JJ.NE.1)I=JJ-1
J1=ORDROW(I)
J2=ORDROW(JJ)
I1=ROUTE(J1)
I2=ROUTE(J2)
K1=ATYPE(J1)
K2=ATYPE(J2)
SEP=2
IF(IPACTV(J1).EQ.1)SEP=4
IF(IPACTV(J1).EQ.3)SEP=3
M2=NOPTYM(J2)
M3=ASSYGN(J1)+TYTOGO(K2,1,SEP)*4
M1=MAXO(M2,M3)
IF(I1.EQ.I2)GOTO 20
IT=MERGE(I1,I2)
T1=TYTOGO(K1,I1,1)*4
T2=TYTOGO(K2,I1,1)*4
IF(T2.GE.T1)GOTO 15
20 ASSYGN(J2)=M1
GOTO 12
15 T3=TYTOGO(K2,IT,SEP)*4
U2=UNITFL(J2)
M2=LENGTH(U2)*4-T2
M4=ENTTYM(J2)+M2
M5=ASSYGN(J1)-T1
M6=M5+T3-T2
M7=MAXO(M4,M6)
ASSYGN(J2)=MAXO(M1,M7+T2)
12 CONTINUE

```

RETURN  
END

```

C      SUBROUTINE COMPAR
C
C      IMPLICIT INTEGER(A-Z)
C
COMMON/CPS/ORDER(10),FCFSNM(9),COUNT,FRSTNM(30),BSTOFF
1  ,MXPERM,TOTLAC,ENTRWF(30),ENTRWS(30),ORDROW(10)
2  ,MORE,NXTROW,LNDCLS(30),PERM(9),ASNNUM(30),NOPERM
3  ,FSTMOR,AMOUNT(9),SWITCH,BSTSWI,BSTORD(10),TIE,OFFRUT,PRIORT
4  ,ASSYGN(30),NOMTYM(30),ASNTYM(30),INFAS,BSTASN(10)
5  ,FRSTPE,SEPMIN(3,3),FINAL,FENTNU(30),LEADTM,MPS,NMTEST
6  ,MXPFAC,ENTTYM(30)
C
COMMON/UPD81/UNITFL(30),ACTYPE(30),ROUTE(30),RECLDC(30),
1  LENGTH(85),NXTARR,RAN1,RAN2,ENTNUM,LSTARR(14),
2  NXTTYP,NXTIPA,NXTRUT,TYTOGO(6,6,4)
C
      IF(MXPERM.EQ.-1)RETURN
      IF(MXPERM.LE.1)GOTO 33
      NMTEST=NMTEST+1
      IF(NMTEST.EQ.1)GOTO 63
      IF(ASSYGN(FIN,L).GT.BSTASN(MXPERM+1))GOTO 13
63  DELAY=0
      SWITCH=0
      IT=MXPERM+1
      DO 23 I=1,IT
      SWITCH=SWITCH+IABS(ORDER(I)-(FRSTNU(FINAL)-MXPERM-1+I))
      TT=MAX(0,ASSYGN(ORDROW(I))-NOMTYM(ORDROW(I)))
      DELAY=DELAY+TT
23  CONTINUE
      IF(NMTEST.EQ.1)GOTO 33
      IF(ASSYGN(FINAL).LT.BSTASN(MXPERM+1))GOTO 33
      IF(DELAY.GT.BSTDEL)GOTO 13
      IF(DELAY.LT.BSTDEL)GOTO 33
      IF(SWITCH.GT.BSTSWI)GOTO 13
      IF(SWITCH.LT.BSTSWI)GOTO 33
53  TIE=TIE+1
      GOTO 13
33  TIE=0
      BSTDEL=DELAY

```

```

BSTSWI=SWITCH
BSTASN(10)=ASSYGN(ORDROW(10))
BSTASN(MXPERM+1)=ASSYGN(FINAL)
BSTORD(MXPERM+1)=ORDROW(MXPERM+1)
IF(MXPERM.LT.1)RETURN
DO 43 I=1,MXPERM
  BSTORD(I)=ORDROW(I)
  BSTASN(I)=ASSYGN(ORDROW(I))
43 CONTINUE
13 CONTINUE
11 CONTINUE
  RETURN
  END
```

```

C      SUBROUTINE MKEFNL
C
C      IMPLICIT INTEGER(A-Z)
C
COMMON/SIGCOM/N1234, IHDUR, MNSEC, NACTV, IGACTV(30),
1 IX(30), IY(30), IALT(30), I:GD(30), IPACTV(30), KODERT(30),
1 N4321, IFLASH(30), ISPD(30), MSG(30), IGACTV(30), NARV,
1 IGARV(10), ITPARV(10), IFFARV(10), ISTA(10), ITARV(10),
1 MSG1, MSG2, IKNT, IZERO, IXB, IYB, IXC, IYC, IFLSH, IDSPBC, IDUM(32)
C
COMMON/SETUP1/UPDATE, DELTA, ARRATE, CLOCK
C
COMMON/SETUP2/SUPREZ, BAKLOG
C
COMMON/HOLD1/NXTFNL, MINTRP, HOLD(30), NXSTAR(30), FINASN(30)
1 , LSTREC(14), STOPAC(30), NEWOUT
C
COMMON/HOLD2/TYMFIN(30), TY2FIN(30), TY2FLY(30), DLTOGO(30)
C
COMMON/UPD81/UNITFL(30), ACTYPE(30), ROUTE(30), RECLOC(30),
1 LENGTH(85), NXTARR, RAN1, RAN2, ENTNUM, LSTARR(14),
2 NXTTYP, NXTIPA, NXTRUT, TYTOGO(6, 6, 4)
C
COMMON/CPS/ORDER(10), FCFSNM(9), COUNT, FRSTNU(30), BSTOFF
1 , MXPERM, TOTLAC, ENTRWF(30), ENTRWS(30), ORDROW(10)
2 , MORE, NXTROW, LNDCLS(30), PERM(9), ASNNUM(30), NOPERM
3 , FSTMOR, AMOUNT(9), SWITCH, BSTSWI, BSTORD(10), TIE, OFFRUT, PRIORT
4 , ASSYGN(30), NOMTYM(30), ASNTYM(30), INFEAS, BSTASN(10)
5 , FRSTPE, SEPMIN(3, 3), FINAL, FENTNU(30), LEADTM, MPS, NMTEST
6 , MXPFAC, ENTTYM(30)
C
COMMON/INFO/ACID(50), ALINE(5), SIZE(3)
C
DATA, NXTFNL, MINTRP, FINASN, HOLD/1, 1424, 200*0/
C
C* DETERMINE IF ANY TENTATIVE ASSIGNMENTS CAN BE FINALIZED
C
IF(ENTNUM EQ. 0) RETURN
DO 10 J=1, ENTNUM

```

```

I=ENTRWS(J)
IF(FINASN(I).NE.G)GOTO 10
U=UNITFL(I)
R=RECLOC(I)-UPDATE
T1=(LENGTH(U)-R+1)*4      !CHECK +1
IT=J+MPS+1
IF(IT.GT.ENTNUM)GOTO 15
JT=ENTRWF(IT)
IF(CLOCK+MINTRP.GT.NOMTYM(JT))GOTO 16
15 CONTINUE
IF(T1.GT.900)GOTO 10
16 CONTINUE
FINASN(I)=1
TYMFIN(I)=CLOCK
TY2FIN(I)=CLOCK-ENTTYM(I)
TY2FLY(I)=ASNTYM(I)-CLOCK
DLTOGO(I)=ASNTYM(I)-CLOCK-T1
T2=DLTOGO(I)/(UPDATE*4)
NXSTAR(I)=CLOCK+T2*UPDATE*4
HOLD(I)=1
IF(DLTOGO(I).LE.0)HOLD(I)=0
DELAY=ASNTYM(I)-NOMTYM(I)
IF(SUPREZ.EQ.1)GOTO 10
I1=IPACTV(I)
DELABS=DELAY-DLTOGO(I)
PRINT 1000,ACID(I),FENTNU(I),SIZE(I1),ROUTE(I),FRSTNU(I),
1 CLOCK,I,ASNTYM(I),DELAY,DELABS,DLTOGO(I)
1000 FORMAT('0 FINAL ASSIGNMENT FOR ',A2,I2,A1,
1 '(ROUTE =',I3,' FCFS =',I4,')',/
2 ' CLOCK =',I6,' POSITION =',I4,
3 ' SCHED =',I6,/' DELAY(TOT) =',I6,' DELAY(ABS) =',
4 I6,' DELAY(TOGO) =',I6)
10 CONTINUE
RETURN
END

```

```

SUBROUTINE OUTR
C
C  IMPLICIT INTEGER(A-Z)
C
COMMON/SIGCOM/N1234, IHOURL, MNSEC, NACTV, IGACTION(30),
1 IX(30), IY(30), IALT(30), IHGD(30), IPACTV(30), KODERT(30),
1 N4321, IFLASH(30), ISPD(30), MSG(30), IGACTION(30), NARV,
1 IGARV(10), ITPARV(10), IFFARV(10), ISTA(10), ITARV(10),
1 MSG1, MSG2, IKNT, IZERD, IXB, IYB, IXC, IYC, IFLSH, IDSPBC, IDUM(32)
C
COMMON/SETUP1/UPDATE, DELTA, ARRATE, CLOCK
C
COMMON/SETUP2/SUPREZ, BAKLOG
C
COMMON/HOLD2/TYMFIN(30), TY2FIN(30), TY2FLY(30), DLTOGO(30)
C
COMMON/DSPDAT/ACTIVE(30), ALFF(30), ILEAD(2, 30), LEADER(2, 3)
C
COMMON/UPD81/UNITFL(30), ACTYPE(30), ROUTE(30), RECLOC(30),
1 LENGTH(85), NXTARR, RAN1, RAN2, ENTNUM, LSTARR(14),
2 NXTTYP, NXTIPA, NXTRUT, TYTOGO(6, 6, 4)
C
COMMON/CPS/ORDER(10), FCFSNM(9), COUNT, FRSTNU(30), BSTOFF
1 , MXPERM TOTLAC, ENTRWF(30), ENTRWS(30), ORDROW(10)
2 , MORF, NXTROW, LNDCLS(30), PERM(9), ASNNUM(30), NOPERM
3 , FSTTOR, AMOUNT(9), SWITCH, BSTSWI, BSTORD(10), TIE, OFFRUT, PRICRT
4 , ASSYGN(30), NOMTYM(30), ASNTYM(30), INFEAS, BSTASN(10)
5 , FRSTPE, SEFMIN(3, 3), FINAL, FENTNU(30), LEADTM, MPS, NMTEST
6 , MXPFAC, ENTTYM(30)
C
COMMON/INFO/ACID(50), ALINE(5), SIZE(3)
C
COMMON/HOLD1/NXTFNL, MINTRP, HOLD(30), NXSTAR(30), FINASN(30)
1 , LSTREC(14), STOPAC(30), NEWOUT
C
REAL X1, X2, X3
C
IF(SUPREZ.EQ.1)GOTO 84
IF(NEWOUT.NE.1)GOTO 84

```

```

C
C* PRINT THE NEW ARRIVAL INFORMATION (IF DESIRED)
C
      IT=ROW(ENTNUM)
      I1=IPACTV(IT)
      PRINT 1009,ENTTYM(IT)
1009 FORMAT('O NEW ARRIVAL AT',I6,' -- ')
      PRINT 1010,ACID(IT),FENTNU(IT),SIZE(I1),ROUTE(IT),
1 FRSTNU(IT),NOMTYM(IT)
1010 FORMAT(' ID =',A2,I2,A1,' ROUTE =',I3,' FCFS =',
1 I4,' NOMARR =',I6/)
      HEAD=1
      DO 83 I=1,ENTNUM
      J=ENTRWS(I)
      IF(FINASN(J).EQ.1)GOTO 83
      IF(HEAD.EQ.0)GOTO 443
      HEAD=0
      PRINT 1008
1008 FORMAT('O',10X,'TENTATIVE AIRCRAFT ASSIGNMENTS'///' LAND
FCFS ',
1 ' ID NOMARR SCHED DELAY'//)
443 DELAY=ASNTYM(J)-NOMTYM(J)
      J1=IPACTV(J)
      PRINT 453,I,FRSTNU(J),ACID(J),FENTNU(J),SIZE(J1),
1 NOMTYM(J),ASNTYM(J),DELAY
453 FORMAT(2X,I3,3X,I3,5X,A2,I2,A1,3(3X,I6))
      83 CONTINUE
      NEWGJT=0
      84 CONTINUE
      IF(ENTNUM.LT.30)RETURN
      IT=ENTRWS(30)
C
C* CHECK FOR THE END OF THE RUN
C
      IF(CLOCK.LT.ASSYGN(IT))RETURN
      DELTA=-9999
C
C* PRINT OUT FINAL STATISTICS
C

```



```

      IF(SUPREZ.EQ.1)GOTO 85
      PRINT 1001
1001  FORMAT('1 LAND      ENT      FCFS      ID      ROUTE  ENTER',
1      ' NOMARR  SCHED  DELAY  TYTOGO',
2      ' DELABS  DEL2GO//')
      GOTO 86
      85 PRINT 1011
1011  FORMAT('0 LAND      ENT      FCFS      ID      ROUTE  ENTER',
1      ' NOMARR  SCHED  DELAY  TYTOGO',
2      ' DELABS  DEL2GO//')
      86 CONTINUE
      T=0
      DO 100 J=1,30
      IT=ENTRWS(J)
      DELAY=ASNTYM(IT)-NOMTYM(IT)
      T=T+DELAY
      I1=IPACTV(IT)
      MM=DLTOGO(IT)
      MN=DELAY-MM
      PRINT 1000,J,FENTNU(IT),FRSTNU(IT),ACID(IT),FENTNU(IT),SIZE(I1),
1  ROUTE(IT),ENTTYM(IT),NOMTYM(IT),ASNTYM(IT),DELAY,
2  TY2FLY(IT),MN,MM
1000  FORMAT(2X,I3,5X,I3,5X,I3,6X,A2,I2,A1,5X,I2,2X,7(16,3X))
      IF(J.NE.30) GOTO 100
      PRINT 1002,T
1002  FORMAT(' TOTAL DELAY = ',I7)
      X1=ENTTYM(30)-UPDATE*4
      X2=108000./X1
      PRINT 1006
1006  FORMAT(' ')
      PRINT 1003,MPS
1003  FORMAT(' MAXIMUM NUMBER OF POSITION SHIFTS = ',I3)
      PRINT 1004,X2
1004  FORMAT(' EFFECTIVE ARRIVAL RATE INTO THE TERMINAL AREA = ',
1  F7.2,' PER HOUR')
      X3=T/30
      PRINT 1005,X3
1005  FORMAT(' AVERAGE DELAY PER AIRCRAFT = ',F7.2,' SECONDS')
      100 CONTINUE

```